भारतीय मानक
Indian Standard

IS 17345 (Part 1) : 2020

पावर ट्रैक सिस्टम

भाग 1 सामान्य आवश्यकताएं

Power Track System

Part 1 General Requirement

ICS 29.060.10; 29.120.10

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Electrical Wiring Accessories and Sectional Committee, ETD 14

FOREWARD

This Indian Standard (Part 1) was adopted by the Bureau of Indian Standards, after the draft finalized by the Electrical Wiring Accessories Sectional Committee had been approved by the Electrotechnical Division Council.

This standard specifies the general requirements for power track systems. This standard is based on IEC 61534-1 : 2011 'Powertrack systems — Part 1: General requirements', issued by the International Electro technical Commission with the following modifications:

a) The single phase ratings has been changed to 240V and 20/25 A.
b) The three pahse ratings ahs been changed to 440 V and 73 A.
c) The frequency has been changed to 50 Hz.
d) The ambient temperature is 45 ± 5°C

The other part in this series is:

Part 21	Particular requirements for power track systems intended for wall and ceiling mounting

The composition of the Committee, responsible for the formulation of this standard is given at Annex H.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules of rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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POWER TRACK SYSTEMS

PART 1 GENERAL REQUIREMENT

1 SCOPE

1.1 This Indian Standard (Part 1) specifies general requirements and tests for powertrack (PT) systems with a rated voltage not exceeding 240 V a.c. single phase with rated current not exceeding 20/25A, or 415 V a.c. two or three phase 50 Hz with a rated current not exceeding 73 A. These systems are used for distributing electricity in household, commercial and industrial premises.

1.2 Powertrack systems, according to this standard, are intended for use under the following conditions:

a) An ambient temperature in the range -5°C to +55°C, the average value over a 24 h period not exceeding 40 °C;
b) A situation not subject to a source of heat likely to raise temperatures above the limits specified above;
c) An altitude not exceeding 2 000 m above sea level;
d) An atmosphere not subject to excessive pollution by smoke, chemical fumes, prolonged periods of high humidity or other abnormal conditions.

In locations where special conditions prevail, as in ships, vehicles and the like and in hazardous locations, for instance, where explosions are liable to occur, special constructions may be necessary.

1.3 This standard does not apply to:

a) cable trunking systems and cable ducting systems covered by IS 14297 (Part 1);
b) busbar trunking systems covered by IEC 60439-2; and
c) electrical supply track systems for luminaires covered by IEC 60570.

2 REFERENCE

The following standards contain provisions, which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreement based on standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

IS No./ International Standard	*Title*
1293 : 2019	Plugs and socket — Outlets of rated voltage up to and including 250 volts and rated current up to and including 16 amperes — Specification (*third revision*)
1401 : 2008	Protection of persons and equipment by enclosures — Probes for verification
2071 (Part 1) : 2016	High voltage test techniques: Part 1 General definitions and test requirements
2824 : 2007	Method for the determination of the proof and the comparative tracking indices of solid insulating materials
9000 (Part 11) : 1983	Basic environmental testing procedures for electronic and electrical items: Part 11 Salt mist test
9000 (Part 7/ Sec 7) : 2006	Basic environmental testing procedures for electronic and electrical items: Part 7 Impact test, Section 7 Test Eh: Hammer tests
12360 : 1988	Voltage bands for electrical installation including preferred voltage and frequency
IS/IEC 60127 (Part 1) : 2006	Miniature fuses: Part 1 Definitions for miniature fuses and general requirements for miniature fuse-links
12857 : 1989	Graphical symbols for use on equipment
IS/IEC 60529 : 2001	Degrees of protection provided by enclosures (IP code)
IS/IEC 60269 (Part 1) : 2014	Low-voltage fuses: Part 1 General requirements
IS/IEC 60695 (Part 2/Sec 11) : 2014	Fire hazard testing: Part 2-11 Glowing/hot-wire based test methods — Glow-wire flammability test methods for end-products

IS No./ International Standard	*Title*
IS/IEC 60998 (Part 1) : 2002	Connecting devices for low-voltage circuits for household and similar purposes: Part 1 General requirements
IEC 60364-4-44 : 2007	Low-voltage electrical installations — Part 4-44: Protection for safety — Protection against voltage disturbances and electromagnetic disturbances
IEC 60664-1 : 2007	Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests
IEC 60695-11-2 : 2003	Fire hazard testing — Part 11-2: Test flames — 1 kW nominal pre-mixed flame — Apparatus, confirmatory test arrangement and guidance
IEC 60695-10-2 : 2003	Fire hazard testing — Part 10-2: Abnormal heat — Ball pressure test
IEC 60998- 2-3 : 2002	Connecting devices for low-voltage circuits for household and similar purposes — Part 2-3: Particular requirements for connecting devices as separate entities with insulation piercing clamping units
IEC 60999-1 : 1999	Connecting devices — Electrical copper conductors — Safety requirements for screw-type and screwless-type clamping units — Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm2 up to 35 mm^2 (included)
IEC 60999-2 : 2003	Connecting devices — Electrical copper conductors Safety requirements for screw-type and screwless-type clamping units — Part 2: Particular requirements for clamping units for conductors above 35 mm2 up to 300 mm^2 (included)
IEC 61210 : 2010	Connecting devices — Flat quick-connect terminations for electrical copper conductors — Safety requirements
ISO 1456 : 2009	Metallic and other inorganic coatings — Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and of copper plus nickel plus chromium
ISO 2081 : 2008	Metallic and other inorganic coatings — Electroplated coatings of zinc with supplementary treatments on iron or steel

3 TERMS AND DEFINITIONS

For the purposes of this standard, the following terms and definitions shall apply:

3.1 Powertrack System PT System — Assembly of system components including a powertrack by which accessories may be connected to an electrical supply at one or more points (pre-determined or otherwise) along the powertrack.

3.2 System Component — Part specifically designed for the PT system which may or may not incorporate an accessory.

3.3 Powertrack — System component which is a generally linear assembly of spaced and supported busbars providing electrical connection of accessories.

NOTE — A powertrack may also provide mechanical support for accessories.

3.4 Busbar — Main current carrying conductor(s) to which for example one or more tap-off units, accessories or electrical system components may be connected.

3.5 Accessory — Electrical device complying with its own standard and associated with or incorporated in the PT system.

3.6 Rewireable Accessory — Accessory so constructed that a cable can be fitted or replaced using a tool.

3.7 Non-Rewirable System Component — System component so constructed that it forms a complete unit with the cable after connection and assembly by the manufacturer of the system component.

3.8 Connector — Device which provides the electrical connection and possibly the mechanical connection of powertracks.

3.9 Supply Connector — Device enabling the supply wiring to be connected to the powertrack.

3.10 Live Parts — conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN conductor.

3.11 Rated Voltage, Rated Current — Value assigned to a PT system by the manufacturer and to which operation and performance characteristics are referred.

3.12 Clamping Unit — Part(s) of a terminal necessary for the mechanical clamping and the electrical connection of the conductor(s) including the parts which are necessary to ensure the correct contact pressure.

3.13 Termination — Part of a PT system to which a conductor(s) is attached providing a non-reusable connection.

3.14 Terminal — Part of the PT system composed of one or more clamping unit(s) to which a conductor(s) is attached providing a reusable connection.

3.15 Insulation Piercing Connecting Device (IPCD) — Connecting device for the connection and possible disconnection of one conductor or the interconnection of two or more conductors, the connection being made by piercing, boring through, cutting through, removing, displacing or making ineffective in some other manner the insulation of the conductor(s) without previous stripping.

NOTE — The removal of the sheath of the cable, if necessary, is not considered as a previous stripping.

3.16 Flat Quick-Connect Termination — Electrical connection consisting of a male tab and a female connector which can be inserted and withdrawn with or without the use of a tool.

3.17 Plug — Accessory intended for connection to a flexible cable intended for frequent manual engagement with a socket outlet.

3.18 Socket-Outlet — Accessory having a set of contacts designed to engage with the pins of a corresponding plug and which may have terminals or terminations for the connection of conductors.

3.19 Fuse-Link — Part of the fuse including the fuse-element(s) and intended to be replaced after the fuse has operated.

3.20 Type Test — Test of one or more PT systems made to a certain design to show that design meets certain specifications.

3.21 Routine Test — Test to which each PT system is subjected during or after manufacture to ascertain whether it complies with the relevant requirements of this standard.

NOTE — The routine test is specified in Annex G.

3.22 Dummy Track — Device for maintaining visual appearance and mechanical integrity, which may be with or without current carrying, parts.

3.23 Tap-off Unit — System component intended for infrequent manual engagement with the busbars directly or indirectly via a tap-off outlet.

3.24 Tap-off Outlet — Aperture into which the tap-off unit engages.

3.25 Clearance — Shortest distance in air between two conductive parts.

3.26 Creepage Distance — Shortest distance along the surface of the insulating material between two conductive parts.

3.27 Overvoltage — Voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions.

3.28 Transient Overvoltage — Short duration overvoltage of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped.

3.29 Overvoltage Category — Numeral defining a transient overvoltage condition

3.30 Rated Impulse Withstand Voltage — Highest peak value of impulse voltage of prescribed form and polarity assigned by the manufacturer and which does not cause breakdown of insulation under specified conditions.

3.31 Rated Insulation Voltage — r.m.s. withstand voltage value assigned by the manufacturer to the PT system or to a part of it, characterising the specified (long term) withstand capability of its insulation.

3.32 Basic Protection — Protection against electric shock under fault-free conditions.

3.33 Fault Protection — Protection against electric shock under single fault conditions (for example, failure of basic insulation).

3.34 Functional Insulation — Insulation between live parts which is necessary only for the proper functioning of the PT system.

3.35 Basic Insulation — Insulation of live parts which provides basic protection against electric shock.

3.36 Supplementary Insulation — Independent insulation as applied as fault protection in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation (fault protection).

3.37 Double Insulation — Insulation comprising both basic insulation and supplementary insulation

3.38 Reinforced Insulation — Insulation of live parts which provides a degree of protection against electric shock equivalent to double insulation.

3.39 Solid Insulation — Insulation material, not gaseous or liquid, interposed between two conductive parts.

3.40 Pollution — Contamination by foreign matter, solid, liquid, or gaseous that can result in a reduction of electric surface resistivity.

3.41 Pollution Degree — Numeral characterising the expected pollution of the microenvironment.

3.42 Micro-Environment — Immediate environment of the insulation which particularly influences the dimensioning of creepage distances.

3.43 Macro-Environment — Environment of the room or other location in which the equipment is installed or used.

3.44 Ordinary Person — Person who is neither a skilled person nor an instructed person.

3.45 (Electrically) Skilled Person — Person with relevant education and experience to enable him or her to avoid dangers and to prevent risks which electricity may create.

3.46 (Electrically) Instructed Person — Person adequately advised or supervised by skilled persons to enable him or her to avoid dangers and to prevent risks which electricity may create.

3.47 Entry Membrane — Component or an integral part of a PT system used to protect the cable and which may be used to support the cable, conduit or ducting or trunking at the point of entry.

NOTE — It may also provide ingress protection.

3.48 Special Purpose Tool — Tool which is unlikely to be readily available in a normal household, for example, a key for a three-angle headed screw.

3.49 Exposed-Conductive-Parts — Conductive part of equipment which can be touched and which is not normally live, but which can become live when basic insulation fails.

NOTE — A conductive part of electrical equipment which can only become live through contact with an exposed-conductive-part which has become live is not considered to be an exposed-conductive-part itself.

3.50 Hazardous-Live-Part — Live part which, under certain conditions can give a harmful electric shock.

3.51 Rated Conditional Short-Circuit Current (I_{cc}) of a Circuit of a PT System — Value of prospective short-circuit current, declared by the PT system manufacturer, that can be withstood for the total operating time (clearing time) of the short-circuit protective device (SCPD) under specified conditions.

NOTES:

1 The test conditions are specified in **18.2** and **18.4**.

2 For a.c., the rated conditional short-circuit current is expressed by the r.m.s. value of the a.c. component.

3 The short-circuit protective device may either form an integral part of the PT system or be a separate unit.

3.52 Short Time Withstand Current — The current that a circuit or a switching device in the closed position can carry during a specified short time under prescribed conditions of use and behaviour

3.53 Noiseless (Clean) Earth — Combined protective and functional earth conductor in which the level of conducted or induced interference from external sources does not produce an unacceptable incidence of malfunction in the data processing or similar equipment to which it is connected. The susceptibility in terms of amplitude/frequency characteristics varies depending on the type of equipment.

3.54 Dry-Treatment of Floor — Process for cleaning and/or care by which the floor is treated without liquids or with only a small quantity of liquid such that no pools or soaking of the floor covering occurs.

EXAMPLE — Sweeping with a broom or carpet-sweeper, vacuum cleaning, brushing, cleaning with a dry cleaning powder, dry shampoo treatment, wet shampooing of carpets, treatment with cleaning litter (liquid chemical cleaning agent on a solid material used as carrier, for example, soaked sawdust, damp cloth, etc.).

3.55 Wet-Treatment of Floor — Process for cleaning and/or care by which the floor is treated with liquid agents such that pools of liquid, or soaking of the floor covering for a brief period of time, cannot be excluded.

EXAMPLE — Wet scrubbing, manual or mechanical wiping.

4 GENERAL REQUIREMENTS

4.1 PT systems shall be so designed and constructed that in normal use their performance is reliable and without unreasonable hazard to the user or the surroundings.

4.2 Compliance is checked by all relevant tests according to this standard and the appropriate Part 2 of this standard.

4.3 Accessories associated with or incorporated in a system component shall and need only comply with the relevant standard for that accessory if any.

5 GENERAL NOTES ON TESTS

5.1 Tests according to this standard are type tests.

5.2 Unless otherwise specified in this standard, the samples shall be tested as delivered under normal or simulated conditions of use, at an ambient temperature of (45 ± 5)°C. The samples used for the tests shall be representative of normal production in respect of all details, which may affect the test results. Unless otherwise specified, samples shall be assembled and mounted in accordance with the manufacturer's instructions. Samples of non-rewireable system components shall be supplied with an appropriate flexible cable, which shall be at least 1 m long.

5.3 Thirteen samples shall be subjected to inspection and tests in the following order of clauses.

Number of Samples	*Clause Number*				
3	8	9	10 (15)[b]	11	14 (10/ 11.1/ 11.3/15.3)[b]
1[a]	14.1 (10/ 11.1/ 11.3/15.3)[b]				
3	12	13	16	17	21 (15.4)[b]
1[d]	18 [c] (11.3.1,15.4)[b]; ([10.2, 10.3, 16.3][e])[b]				
3	19				
1	20.1				
1	20.2				

[a] For the cold test.

[b] The clauses in parenthesis indicate tests that are referenced from the preceding main test clause.

[c] The short circuit tests shall be performed on a new sample.

[d] The tests may be carried out on one sample or each test may be carried out on a new sample at the manufacturer's discretion.

[e] Tests required only in case of doubt.

Unless otherwise specified, a sample means an individual component, a powertrack not less than 1 m in length, or a combination typifying the system as a whole.

5.4 Unless otherwise specified, three samples shall be subjected to the tests. The requirements are satisfied if all samples meet the test requirements. If any of the samples fails to satisfy the test requirements due to an assembly or manufacturing fault then that test and any preceding test, which may have influenced the results, shall be repeated and any subsequent tests in the sequence shall be applied to another full set of samples. All of the new set of samples shall comply with the requirements.

6 RATINGS

PT systems shall have:

a) Single phase with rated current not exceeding 20/25 A with the rated voltage of 240 V a.c.; and
b) Two or three phase 50 Hz with a rated current not exceeding 73 A and rated voltage 415 V a.c.

7 CLASSFICATION

PT systems and/or system components shall be classified as follows:

7.1 According to resistance to impact for installation and application.

7.1.1	PT system for light impact:	1 J
7.1.2	PT system for medium impact:	2 J
7.1.3	PT system for heavy impact:	5 J
7.1.4	PT system for very heavy impact:	20 J

7.2 According to whether the tap-off units are intended to be connected and disconnected with the system energised and/or their load connected.

7.2.1 Tap -off units not intended to be connected or disconnected when the system is energised.

7.2.2 Tap-off units intended to be connected or disconnected when the system is energised but without a load connected.

7.2.2.1 By ordinary person, skilled person or instructed person.

7.2.2.2 By skilled person or instructed person.

7.2.3 Tap-off units intended to be connected or disconnected when the system is energised and with a load connected.

7.3 According to degrees of protection provided by enclosures according to IS/IEC 60529.

7.3.1 According to protection against ingress of solid foreign objects.

7.3.2 According to protection against ingress of water.

7.4 According to degree of pollution.

7.4.1 Pollution degree 1.

7.4.2 Pollution degree 2.

7.4.3 Pollution degree 3.

NOTES:

1 Details for the pollution degrees are given in Annex D.

2 A PT system suitable for use in a particular situation may be used in a less polluted situation.

7.5 According to the rated impulse withstand voltage:

330 V, 500 V, 1 500 V, 2 500 V, 4000 V.

NOTE — The relationship between rated impulse withstand voltage, rated voltage and overvoltage category is given in Annex C.

8 MARKING AND DOCUMENTATION

8.1 Each system component shall be marked with:

a) the name or trade mark of the manufacturer or responsible vendor; and
b) product identification which may comprise, for example, a colour, a catalogue number, a symbol.

In the case where the PT system is supplied as an assembly then only the assembly need be marked, and this shall not be on easily removable parts.

NOTE — where it is not possible to mark a component due to its size, then it will be sufficient to mark the smallest package unit according to **8.1**.

Compliance is checked by inspection.

8.2 In addition to **8.1** the powertrack, tap-off units and supply connectors shall be marked with:

a) rated voltage in volt,
b) rated current in ampere,
c) nature of supply for example, 50 Hz, 60 Hz.

If symbols are used, they shall be in accordance with **8.7**.

Compliance is checked by inspection.

8.3 Line, neutral and earth terminals for external conductors shall be marked using the symbols in accordance with **8.7**; alternatively these marks can be placed adjacent to the terminal.

Compliance is checked by inspection.

8.4 If necessary for correct installation, for example for screwless type or insulation piercing terminals, the following information shall be given by marking adjacent to terminals:

a) connection and disconnection procedure; and
b) cross-sectional areas and types of connectable conductors.

NOTE — Type of connectable conductors could include solid, stranded, flexible, copper or aluminium.

Alternatively the information may be given on the smallest package unit or in the manufacturer's installation instructions.

In addition, the location of protective devices, such as fuses, circuit breakers and residual current devices which are not visible after installation shall be marked in their vicinity with the appropriate symbol or text which shall be visible after installation. In the case of fuses or other protective devices which can be replaced without the use of a tool, the appropriate current shall also be marked and if necessary, the appropriate voltage.

Compliance is checked by inspection.

8.5 The manufacturer or responsible vendor shall provide documentation giving the information necessary for the proper and safe installation and use of the PT system for:

a) system components of the PT system;
b) the purpose of the system components and their assemblies;
c) the classification of the PT system according to **7**;
d) guidance to reach the declared performance;
e) guidance regarding periodic inspection and/or maintenance where required;
f) static loading characteristics (*see* **14.3**), if any;
g) the short-circuit performance in accordance with **18.3**; and
h) maximum and minimum cross-sectional areas of cables that the supply terminals are able to accommodate.

Compliance is checked by inspection.

8.6 Information according to **8.1**, **8.2**, **8.3**, **8.4** and **8.5** which is provided with the smallest package unit or in the manufacturer's installation instructions shall be in the form of illustrations and/or in a language which is acceptable to the country in which the PT system is intended to be installed.

Compliance is checked by inspection.

8.7 Symbols

Ampere	A
Volt	V
Hertz	Hz
Alternating current	[IS 12857] or a.c.
Line	L, or, in the case of more than one, L1, L2, L3, etc.
Neutral	N
Protective earth	⏚ IS 12857
Noiseless (clean) earth	⏚
Fuse	⏛ IS 12857
IP code according to IS/IEC 60529	IPXX

For the marking of rated current and rated voltage, figures may be used alone. The figure for the rated current shall be placed before or above that for the rated voltage and separated from the latter by a line. If the symbol for the nature of supply is used, it shall be placed next to the marking for rated current and rated voltage.

For example, 10 A 250 V ~ or 10/250 ~ or $\frac{10}{250}$ ~

Compliance is checked by inspection.

8.8 Marking on the product shall be easily legible and durable.

The marking according to **8.2**, **8.3** and **8.4** shall not be placed on easily removable parts and screws or washers.

Compliance is checked by inspection, using normal or corrected vision, without additional magnification and by rubbing the marking by hand for 15 s with a piece of cotton cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit or 95+ percent n-hexane.

After the test, marking shall be legible. Labels shall not be easily removable and shall not have curled.

NOTES:

1 Petroleum spirit is defined as the aliphatic solvent hexane with a content of aromatics of maximum 0.1 percent volume, a kauri butanol value of 29, initial boiling point 65°C, a dry point of 69 °C and a density of approximately 0.68 g/cm^3.

2 Marking on the product may be applied, for example, by moulding, pressing, engraving, printing, adhesive labels or waterslide transfers.

3 The durability of marking made by engraving, moulding or pressing is deemed to comply with the requirements without testing.

4 95+ percent n-hexane (Chemical Abstracts Service Registry Number, CAS RN, 110-54-3) is available from a variety of chemical suppliers as a high pressure liquid chromatography (HPLC) solvent.

9 CONSTRUCTION

9.1 For tap-off units classified according to **7.2.1** it shall not be possible to connect or disconnect the tap- off unit without the use of a tool, unless the design of the tap-off unit is such that it is not possible to connect or disconnect the tap-off unit with the PT system energised.

Compliance is checked by inspection and by manual test.

9.2 For tap-off units classified according to **7.2.2.1** it shall not be possible to connect or disconnect the tap-off unit under load.

Compliance is checked by inspection and by manual test.

9.3 For tap -off units classified according to **7.2.2.2** the tap- off unit shall be clearly marked to indicate that it shall not be connected or disconnected under load and shall only be accessible by the use of a tool or intended to have restricted access by an ordinary person.

NOTE — Examples of tap-off units having restricted access by an ordinary person include:

a) tap-off units situated under a raised access floor; and

b) tap-off units situated either > 2.5 m above floor level or within a suspended ceiling.

Compliance is checked by inspection and by manual test.

9.4 For non-rewirable system components, it shall not be possible to break the terminations and/or replace the cable without making the system component permanently useless.

Compliance is checked by inspection and if necessary by manual test.

9.5 System components with the provision for fuse-links shall be so designed that ordinary persons cannot gain access to live parts when replacing fuse-links.

Compliance is checked by inspection and test according to **11.1.1.1**.

9.6 PT systems shall be designed so that they do not damage the insulation of conductors or the sheath of cables during installation or in normal use.

Compliance is checked by inspection.

9.7 PT systems including tap-off units intended for use with flexible cables shall be so designed that, if a flexible cable is fitted which may be moved in normal use, a cord anchorage shall be provided such that the conductors are relieved from strain by resisting the pull and twist forces on flexible cables, where they are connected to the terminals and the sheath of the flexible cable is kept in position and is protected from abrasion. It shall be clear how the relief from strain and the prevention of twisting is intended to be effected. Methods, such as tying the cable into a knot or tying the ends with a string shall not be used.

Cord anchorages shall be of insulating material or, if of metal, shall be provided with an insulating lining fixed to the metal parts.

Cord anchorages shall be so designed that:

a) the flexible cable cannot be released from the outside of the system component without the aid of a tool;

b) the flexible cable cannot touch the clamping screws of the cord anchorage, if these screws are accessible or electrically connected to accessible metal parts, when the system component is mounted as in normal use;

c) the flexible cable is not clamped by a metal screw which bears directly on to the flexible cable;

d) at least one part of it is securely fixed to the system component;

e) clamping the flexible cable does not require the use of a special purpose tool;

f) they are suitable for the types and dimensions of flexible cable declared by the manufacturer;

g) clamping the flexible cable is easily possible without restricting the correct re-assembly of the system component;

h) means, such as screws or other fixing devices which are used when clamping the flexible cable shall not serve to fix other parts of the system component unless either:

    1) the system component would be rendered manifestly incomplete if that part was omitted or replaced in an incorrect position, or

    2) that part intended to be fixed cannot be removed without further use of a tool.

j) it shall not be possible to push the flexible cable into the PT system to such an extent as would impair safety or so that the cord anchorage becomes ineffective.

Compliance is checked by inspection, manual tests and the tests according to **9.7.2** and **9.7.3** following the preparation of the sample according to **9.7.1**.

9.7.1 The system component is fitted with a flexible cable of the appropriate cross-sectional area and with the minimum dimensions specified in **9.7**, item f). The conductors are introduced into the terminals and the terminal screws are tightened just sufficiently to prevent the position of the conductors from easily changing. Clamping screws, if any, shall be tightened with the torque value declared by the manufacturer or in the absence of this information with the value according to Table 5.

Non-rewirable system components and their flexible cables are subjected to the test as delivered.

9.7.2 The flexible cable is then subjected 100 times to a pull as specified in Table 1. The pulls are applied in the most unfavourable direction. Each pull is applied in one smooth and continuous motion for a duration of approximately 1 s.

NOTE — Care should be taken to exert the same pull on all parts (core, insulation and sheath) of the cable simultaneously.

Immediately afterwards, t he flexible cable is subjected to a torque, as specified in Table 1, for (60 ± 5) s. The torque is applied as near as practicable to the cord entry.

After the test, the cable shall not have been displaced longitudinally by more than 2 mm. For a rewireable system component, the ends of the conductors shall not have moved noticeably in the terminals, for a non-rewireable system component, there shall be no break in the electrical connections. Clearances and creepage distances shall not have been reduced below the values specified in **10** and the cord anchorage shall show no damage impairing its further use.

For the measurement of the longitudinal displacement, a mark is made on the flexible cable while it is subjected to the pull, at a distance of approximately 20 mm from the end of the sample, before starting the tests. If, for non-rewireable system component, there is no definite end to the sample, an additional mark is made on the body of the sample.

After the tests, the displacement of the mark on the flexible cable in relation to the sample is measured while the flexible cable is still subjected to the pull.

NOTE — Examples of test apparatus are shown in Fig. 1 and Fig. 2.

Table 1 Pull and Torque Values for Tests on Cord Anchorages

(*Clause* 9.7.2)

Sl No.	**Nominal Cross-sectional Area of Conductor** mm^2	**Pull** N	**Torque** Nm
(1)	(2)	(3)	(4)
i)	Up to and including 0.5	50 ± 1.0	0.15 ± 0.02
ii)	Over 0.5 up to and including 1.5	60 ± 1.0	0.25 ± 0.02
iii)	Over 1.5 up to and including 4.0	80 ± 1.0	0.35 ± 0.02
iv)	Over 4.0 up to and including 10.0	100 ± 1.0	0.45 ± 0.02
v)	Over 10 up to and including 16.0	120 ± 1.0	0.80 ± 0.02

NOTE — Pull and torque values do not vary with the number of conductors in the flexible cable.

9.7.3 The tests of **9.7.2** are then repeated with a flexible cable of the appropriate type and cross-sectional area, having a maximum dimension specified in **9.7**, item f).

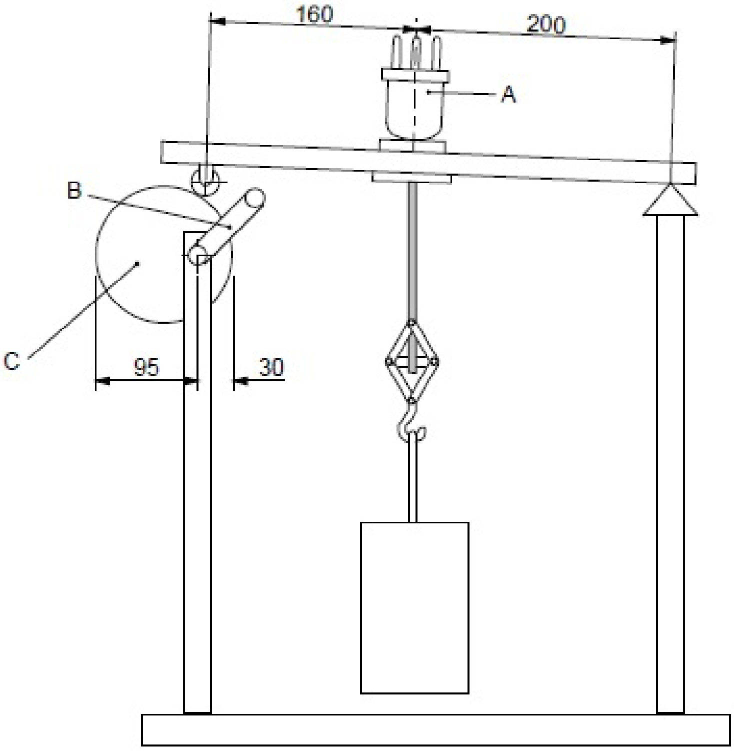
9.8 Resistance to Ageing of Seals

9.8.1 Sealing components shall be sufficiently resistant to ageing:

a) for elastomeric or thermoplastic material compliance is checked according to **9.8.2**; and

b) for polymeric materials having a sticky or oily consistency compliance is checked according to **9.8.3**.

9.8.2 The test is made in an atmosphere having the composition and pressure of ambient air. The samples are suspended freely in a heating cabinet, ventilated by natural circulation.

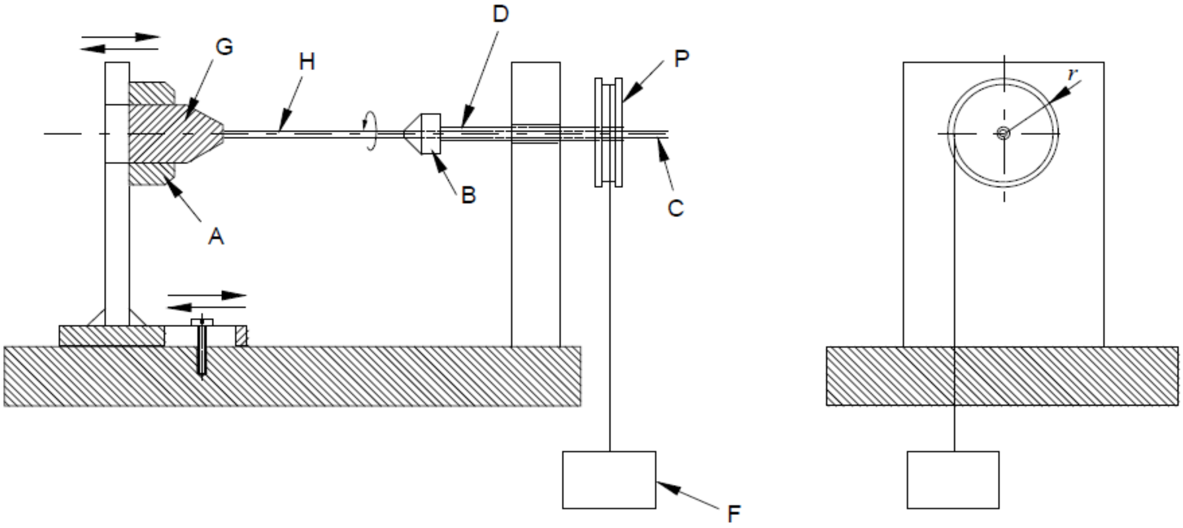


Key

A	Sample
B	Crank
C	Eccentric

Dimensions in millimetres.

FIG. 1 PULL APPARATUS FOR TESTING THE CORD ANCHORAGE



Key

A	Device for fixing the body of sample
B	Device for fixing the cord of sample
C	End of cord
D	Rotary shaft (hollow)
r	Radius of pulley
F	Weight; torque = $F \times r$
P	Pulley
G	Sample
H	Cord

FIG. 2 TORQUE APPARATUS FOR TESTING THE CORD ANCHORAGE

The temperature shall be (70 ± 2)°C measured not more than 5 cm above the sample and the duration of the ageing test shall be (168^{+4}_{0}) h.

After the treatment, the samples are allowed to attain approximately room temperature, they are examined and shall show no crack visible with normal or corrected vision without additional magnification, nor shall the material have become sticky or greasy, this being judged as follows:

With the forefinger, wrapped in a dry piece of rough cloth, the sample is pressed with a force of 5 N.

No traces of the cloth shall remain on the sample and the material of the sample shall not stick to the cloth.

After the test, the samples shall show no damage which would lead to non-compliance with this standard.

The force of 5 N can be obtained in the following way. The component is placed on one of the pans of a balance and the other pan is loaded with a mass equal to the mass of the component, plus 500 g. Equilibrium is then restored by pressing the system components with the forefinger wrapped in a dry piece of rough cloth.

The use of an electrically heated cabinet is recommended. Natural circulation may be provided by holes in the walls of the cabinet.

9.8.3 The test is made in an atmosphere having the composition and pressure of ambient air. The samples are suspended freely in a heating cabinet, ventilated by natural circulation.

The temperature shall be (70 ± 2)°C measured not more than 5 cm above the sample and the duration of the ageing test shall be ($168\,^{+4}_{0}$) h.

After the treatment, the samples are removed from the cabinet and kept at room temperature for ($96\,^{+4}_{0}$) h.

After the test the sample shall show no harmful deformation or similar damage which may impair their further use within the meaning of this standard.

10 CLEARANCES, CREEAGE DISTANCES AND SOLIDS INSULATION

10.1 General

PT systems shall be constructed so that the clearances, creepage distances and solid insulation are adequate to withstand the electrical, mechanical and thermal stresses taking into account the environmental influences that may occur.

Clearances, creepage distances and solid insulation shall comply with the relevant sub-clauses **10.2** to **10.4**.

NOTE — the requirements and tests are based on IEC 60664-1.

10.2 Clearances

10.2.1 *General*

The clearances shall be dimensioned to withstand the rated impulse voltage declared by the manufacturer according to **7.5** considering the rated voltage and the overvoltage category as given in Annex C and the pollution degree declared by the manufacturer according to **7.4**.

PT systems fall into the overvoltage category III.

NOTES:

1 A flow chart for the dimensioning of clearances is given in Annex E.

2 Energy consuming equipment fitted to a PT system falls into overvoltage category II.

For the measurements all parts which may be removed without the use of a tool are removed and movable parts which can be assembled in different orientations are placed in the most unfavourable position.

NOTE — Moveable parts are for example, hexagonal nuts, the position of which cannot be controlled throughout an assembly.

A force is applied, by means of test probe 11 of IS 1401, to bare conductors and accessible surfaces in order to attempt to reduce clearance when making the measurements.

The force is:

a) 2 ± 0.1 N for bare conductors; and
b) 50 ± 2 N for accessible surfaces.

Clearances are measured according to Annex A.

10.2.2 *Clearances for Basic Insulation*

The clearances for basic insulation shall not be less than the values given in Table 2.

Smaller clearances than those given in Table 2 may be used if the PT system withstands an impulse voltage but only if the parts are rigid or positioned by mouldings or if the construction is such that there is no likelihood of the distances being reduced by distortion, by movement of the parts or during mounting and connection in normal use.

Compliance is checked by the test of Annex F.

10.2.3 *Clearances for Functional Insulation*

The clearances for functional insulation shall not be less than the values specified for basic insulation in **10.2.2**.

Compliance is checked by inspection and by measurement.

10.2.4 *Clearances for Supplementary Insulation*

The clearances for supplementary insulation shall not be less than the values specified for basic insulation in **10.2.2**.

Compliance is checked by inspection and by measurement.

10.2.5 *Clearances for Reinforced Insulation*

The clearances for reinforced insulation shall not be less than the values specified for basic insulation in **10.2.2** but using the next higher step for rated impulse withstand voltage given in Table 2.

Smaller clearances than those specified in Table 2 are not allowed.

Compliance is checked by inspection and by measurement.

10.3 Creepage Distances

10.3.1 *General*

The creepage distances shall be dimensioned for the voltage which is expected to occur in normal use taking into account the pollution degree as declared by the manufacturer according to **7.4** and the material group.

NOTES:

1 A flow chart for the dimensioning of creepage distances is given in Annex E.

2 A creepage distance cannot be less than the associated clearance.

For the measurements all parts which may be removed without the use of a tool are removed and movable parts which can be assembled in different orientations are placed in the most unfavourable position.

NOTE — Moveable parts are for example, hexagonal nuts, the position of which cannot be controlled throughout an assembly.

A force is applied, by means of test probe 11 of IS 1401, to bare conductors and accessible surfaces in order to attempt to reduce creepage distances when making the measurements.

The force is:

a) 2 ± 0.1 N for bare conductors; and
b) 50 ± 2 N for accessible surfaces.

Creepage distances are measured according to Annex A.

The relationship between material group and proof tracking index (PTI) values is as follows:

Material group I	$600 \leq \text{PTI}$
Material group II	$400 \leq \text{PTI} < 600$
Material group IIIa	$175 \leq \text{PTI} < 400$
Material group IIIb	$100 \leq \text{PTI} < 175$

These PTI values are obtained in accordance with the proof-tracking test of Annex B.

NOTE — For glass, ceramics and other inorganic materials which do not track, creepage distances need not be greater than their associated clearance.

10.3.2 *Creepage Distances for Basic Insulation*

The creepage distances for basic insulation shall not be less than the values given in Table 3.

Compliance is checked by measurement.

Table 2 Minimum Clearances for Basic Insulation

(*Clauses* 10.2.2 and 10.2.5)

Sl No.	**Rated Impulse Withstand Voltage** kV [a)]	**Minimum Clearances in Air up to 2 000 m Above Sea Level** mm		
		Pollution degree [b)]		
(1)	(2)	(3)	(4)	(5)
i)	0.33	0.01	0.2	0.8
ii)	0.50	0.04	0.2	0.8
iii)	0.80	0.10	0.2	0.8
iv)	1.5	0.5	0.5	0.8
v)	2.5	1.5	1.5	1.5
vi)	4.0	3.0	3.0	3.0
vii)	6.0	5.5	5.5	5.5

[a)] This voltage is:

a) for functional insulation: the maximum impulse voltage expected to occur across the clearance;
b) for basic insulation directly exposed to or significantly influenced by transient overvoltage from the low-voltage mains: the rated impulse withstand voltage of the PT system; and
c) for other basic insulation: the highest impulse voltage that can occur in the circuit.

[b)] Details for pollution degrees are given in Annex D.

10.3.3 *Creepage Distances for Functional Insulation*

The creepage distances for functional insulation shall not be less than the values of basic insulation in **10.3.2**.

Compliance is checked by measurement.

10.3.4 *Creepage Distances for Supplementary Insulation*

The creepage distances for supplementary insulation shall not be less than the values specified for basic insulation in **10.3.2**.

Compliance is checked by measurement

10.3.5 *Creepage Distances for Reinforced Insulation*

The creepage distances for reinforced insulation shall be twice the creepage distances for basic insulation in Table 3.

Compliance is checked by measurement.

10.4 Solid Insulation

Solid insulation for functional insulation, basic insulation, supplementary insulation and reinforced insulation shall be capable of withstanding electrical stress, which may occur.

Compliance is checked by **15**.

In addition, accessible solid insulation shall be capable of withstanding mechanical and thermal stresses, which are covered by **14** and **19**.

11 PROTECTION AGAINST ELECTRIC SHOCK

11.1 Access to Live Parts

11.1.1 PT systems shall be so constructed that when installed as in normal use, hazardous– live-parts are not accessible without the use of a tool.

Table 3 Minimum Creepage Distances for Basic Insulation

(*Clauses* 10.3.2 and 10.3.5)

Rated Voltage r.m.s. [a] V	**Creepage Distance** (mm)						
	Pollution Degree [b]						
	1	**2**			**3**		
Up to and Including		**Material Group**			**Material Group**		
		I	**II**	**IIIa / IIIb**	**I**	**II**	**IIIa / IIIb**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
12.5[c]	0.1	0.4	0.4	0.4	1	1	1
32[c]	0.1	0.5	0.5	0.5	1.3	1.3	1.3
50[c]	0.2	0.6	0.9	1.2	1.5	1.7	1.9
100	0.3	0.7	1	1.4	1.8	2	2.2
125	0.3	0.8	1.1	1.5	1.9	2.1	2.4
250	0.6	1.3	1.8	2.5	3.2	3.6	4.0
400	1.0	2.0	2.8	4.0	5.0	5.6	6.3
500	1.3	2.5	3.6	5.0	6.3	7.1	8.0
800	2.4	4	5.6	8	10	11	12.5
1 000	3.2	5	7.1	10	12.5	14	16

NOTE — The rated voltage is the actual voltage, which will occur across the insulation where the creepage distance is determined.

[a] This voltage is the voltage rationalised through Table F.3a and Table F.3b of IEC 60664-1 based on the rated voltage.

[b] Details for pollution degrees are given in Annex D.

[c] Concerning ELV the last paragraph of **11.1** should be considered.

PT systems shall be so constructed that the engagement of one or more pins of a tap-off unit does not leave pins or contacts of the tap-off unit accessible.

Live parts of tap-off units intended to be connected with the PT energised shall not be accessible when the tap-off unit is in partial engagement with the powertrack.

The insulating properties of lacquer, enamel, paper, cotton or oxide film on metal parts, beads and sealing compounds shall not be relied upon to give the required protection against contact with live parts.

NOTE — Self hardening resins are not regarded as sealing compounds.

Compliance is checked by inspection and, if necessary, by the tests of **11.1.1.1** and **11.1.1.2.**

The tests are carried out after all parts, which may be removed without the use of a tool, are removed and after the following treatment:

a) a representative combination of system components typifying the PT system shall be mounted as in normal use and kept for $(168\,{}^{1}_{0})$ h placed in a heating cabinet at (60 ± 2)°C and then allowed to cool to ambient temperature.

11.1.1.1 The test probe B of IS 1401 is applied with a force of (10 ± 1) N, an electrical indicator with a voltage not less than 40 V and not more than 50 V being used to show contact with the relevant part.

For those PT systems or parts of those PT systems that are accessible without the use of a tool to ordinary persons in normal use, the test is repeated with the test probe D of IS 1401 with a force of (1 ± 0.1) N.

NOTE — Small gaps between enclosures and conduits or cables are ignored.

11.1.1.2 Parts which are likely to distort under external pressure are additionally tested with test probe 11 of IS 1401 with a force of (50 ± 2) N for 1 min at an ambient temperature of (35 ± 2)°C. If the test probe enters the enclosure then it is replaced by test probe B of IS 1401 that is applied as specified in **11.1.1.1**.

Entry membranes and knockouts are tested with (10 ± 1) N.

11.1.2 Exposed-conductive-parts of PT systems, with the exception of small parts, such as screws, shall be reliably connected to the protective earth terminal of the PT system.

Compliance is checked by inspection and the test of **11.3.1**.

11.2 Provision for Earthing

11.2.1 A protective earth conductor shall extend for the whole of the PT system. Where the conductor is part of the mechanical construction of the PT system, it shall not be possible to remove this part of the mechanical construction without the use of a tool.

Compliance is checked by inspection and manual test.

11.2.2 Tap-off units of the PT system intended to be connected with the PT energised shall ensure that connection to the PE is made before and is broken after, those to live parts.

Compliance is checked by inspection, or by the use of an appropriate test instrument.

NOTE — This clause does not apply to SELV PT systems.

11.3 Effectiveness of Protective Circuit Continuity

The continuity of the protective circuit shall be effective in a PT system including the connection of tap-off units.

Compliance is checked by inspection and by the tests of **11.3.1** and **11.3.2**.

11.3.1 For PT systems the test shall be performed on a sample consisting of three lengths of powertrack, each with a minimum length of 1 m which are connected together with the necessary connectors and with a supply connector at each end of the sample.

A current of (25 ± 1) A a.c. having a nominal frequency of 50 Hz supplied by a source with a no-load voltage not exceeding 12 V shall be passed between the earthing terminals at either end of the sample.

Measurement of the voltage drop shall be made within 120 s after the initiation of the current flow.

The impedance per meter, calculated from the measurement of the voltage drop between the two supply connectors, shall not exceed the value declared by the manufacturer or 50 mΩ/m whichever is the lower.

11.3.2 For tap -off units a current of (25 ± 1) A a.c. having a nominal frequency of 50 Hz to supplied by a source with a no-load voltage not exceeding 12 V shall be passed between the earthing terminal or contact of the tap-off unit and the nearest point on the protective earth busbar with the tap-off unit fully engaged as in normal use.

Measurement of the voltage drop shall be made within 120 s after the initiation of the current flow.

The impedance calculated from the measurement of the voltage drop between the two points stated shall not exceed the value declared by the manufacturer or 50 mΩ whichever is the lower.

11.3.3 The effectiveness of the connection of the exposed conductive parts to the protective circuit shall be measured as follows:

A current of (25 ± 1) A a.c. having a nominal frequency of 50 Hz supplied by a source with a no-load voltage not exceeding 12 V shall be passed between the exposed conductive part and the point on the protective circuit which is nearest to the exposed conductive part.

Measurement of the voltage drop shall be made within 120 s after the initiation of the current flow.

The impedance calculated from the measurement of the voltage drop between the two points stated shall not exceed 50 mΩ.

12 TERMINALS AND TERMINATIONS

12.1 Terminals and terminations shall provide effective electrical connections.

12.2 Supply connector terminals shall be positioned in a mounted PT system in such a way that conductors can be properly connected and disconnected and that such terminals can be inspected, for example, by removing a cover.

The manufacturer shall state the rated connecting capacity of the terminals.

The minimum connecting capacity of the terminals shall not be less than the values given in Table 4.

Compliance is checked by inspection and by connection of the relevant cable conductors with cross-sectional areas as given in Table 4.

Table 4 Minimum Connecting Capacity of Terminals

(*Clause* 12.2)

Sl No.	Rated Current of the Terminal A	Minimum Connecting Capacity mm^2
(1)	(2)	(3)
i)	10	1.5
ii)	16	1.5
iii)	20	2.5
iv)	32	4
v)	45	6
vi)	63	10

12.3 Terminals for external conductors shall not require the use of a special purpose tool.

Terminals for external conductors shall be of the following types:

a) screw-type terminal; and
b) screwless-type terminal.

Flat quick-connect terminations are not allowed.

Compliance is checked by inspection.

12.4 Connections to conductors, cables or flexible cables within non-rewireable system components shall be made by means of terminations.

Compliance is checked by inspection.

12.5 Terminations shall be soldered, welded, crimped or have equally effective permanent connection and shall withstand pull forces likely to occur in normal use.

Compliance is checked by inspection and by the following test.

Terminations shall be tested by applying a pull force of (30 ± 2) N in the longitudinal axis of the conductors in the normal plane of exit from the system component. There shall be no deterioration of the soldered, welded, crimped or similar joint impairing their further use.

12.6 Terminals for external conductors with screw-type clamping units or with screwless-type clamping units shall meet the requirements of IEC 60999-1 and IEC 60999-2 except as follows:

a) In subclause **8.9** of IEC 60999-1, the test of **9.6** does not apply.

NOTE — Depending on the design of the PT system it may be necessary to perform the tests for screwless-type clamping units on separate samples.

12.7 Terminals with insulation piercing clamping units for external conductors shall meet the requirements of IEC 60998-2-3 except as follows:

a) Clause **5**: samples according to Annex AA have to be submitted separately;
b) Clause **9**: does not apply. This requirement is covered by clause **11** of this standard;
c) Clause **12** does not apply. This requirement is covered by the clause **17** and subclauses **9.8** and **21.2** of this standard;
d) Clause **13**: does not apply. This requirement is covered by Clause 15 of this standard;
e) Clause **14**: **14.2** and **14.3** of IS/IEC 60998-1 are applicable if the IPCDs are delivered as separate accessories and are mounted on the PT system during installation;
f) Clause **18**: does not apply. This requirement is covered by clause **20** of this standard.

12.8 Connections, other than soldered connections, shall not be made on to pre -soldered ends of conductors unless the soldered area is entirely outside the termination or clamping unit.

Compliance is checked by inspection.

12.9 Flat quick-connect terminations used internally shall have dimensions in accordance with IEC 61210 and shall meet the test requirements of IEC 61210, except as follows:

a) Clause **7**: samples as specified in Table 3 have to be submitted separately; and
b) Subclause **8.6**: applies only in cases where pull forces on crimp connections may be expected during installation and/or normal use of the PT system.

13 SCREWS, CURRENT CARRYING PARTS AND CONNECTIONS

13.1 Connections, electrical or mechanical shall withstand the mechanical stresses occurring in normal use.

Screwed connections, which transmit contact pressure for electrical purposes and which are operated when connecting and mounting the PT system during installation, and/or which are likely to be operated during the life of the system, shall be in engagement with a metal thread.

Screws for connecting external conductors shall not be tapping screws.

Screws operated when mounting the PT system during installation and/or which are likely to be operated during the life of the PT system, shall not be of the thread cutting type.

NOTE — Screws which are operated when mounting the PT system include screws for fixing covers or cover plates, etc., but not connecting means for screwed conduits and screws for fixing the base of the system.

Compliance is checked by inspection and the following test.

The screws and nuts are tightened and loosened

a) 10 times for metal screws in engagement with a thread of insulating material and for screws of insulating material; and
b) 5 times in all other cases.

Screws or nuts in engagement with a thread of insulating material and screws of insulating material are completely removed and reinserted each time.

The test is made by means of a suitable test screwdriver or spanner applying the torque declared by the manufacturer. In the absence of this information, the values specified in Table 5 shall be applied.

The shape of the blade of the test screwdriver shall suit the head of the screw to be tested.

The screws and nuts shall be tightened in one smooth and continuous motion.

During the test, no damage impairing the further use of the screwed connection shall occur.

Table 5 Torque Values for Screws

(*Clause* 13.1)

Sl No.	Nominal Diameter of Thread mm	Torque Nm				
		I[a]	II[b]	III[c]	IV[d]	V[e]
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Up to and including 1.6	0.05	-	0.10	0.10	-
ii)	Over 1.6 up to and including 2.0	0.10	–	0.20	0.20	–
iii)	Over 2.0 up to and including 2.8	0.20	–	0.40	0.40	–
iv)	Over 2.8 up to and including 3.0	0.25	–	0.50	0.50	–
v)	Over 3,0 up to and including 3,2	0.30	–	0.60	0.60	–
vi)	Over 3.2 up to and including 3.6	0.40	–	0.80	0.80	–
vii)	Over 3.6 up to and including 4.1	0.70	1.20	1.20	1.20	1.20
viii)	Over 4.1 up to and including 4.7	0.80	1.20	1.80	1.80	1.80
ix)	Over 4.7 up to and including 5.3	0.80	1.40	2.00	2.00	2.00
x)	Over 5.3 up to and including 6.0	1.20	1.80	2.50	3.00	3.00
xi)	Over 6.0 up to and including 8.0	2.50	2.50	3.50	6.00	4.00
xii)	Over 8.0 up to and including 10.0	–	3.50	4.00	10.0	6.00
xiii)	Over 10.0 up to and including 12.0	–	4.00	–	–	8.00
xiv)	Over 12.0 up to and including 15.0	–	5.00	–	–	10.0

[a] Applies to screws without heads, if the screw, when tightened, does not protrude from the hole, and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the diameter of the screw.

[b] Applies to nuts of mantle clamping units which are tightened by means of a screwdriver.

[c] Applies to other screws of clamping units which are tightened by means of a screwdriver.

[d] Applies to screws and nuts, other than nuts of mantle clamping units, which are tightened by means other than a screwdriver.

[e] Applies to nuts of mantle clamping units, which are tightened by means other than a screwdriver.

13.2 Electrical connections shall be so designed that:

a) the joints shall not become loose in normal use; and

b) contact pressure is not transmitted through insulating material other than glazed ceramic, pure mica or other material with characteristics no less suitable, unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage or yielding of the insulating material.

Compliance is checked by inspection, and if there is insufficient resiliency by the test according to **15.102** of IEC 60998-2-3.

13.3 Thread forming screws shall not be used for the connections of current carrying parts.

Thread forming screws may be used to provide earthing continuity provided it is not necessary to operate them during normal use of the PT system.

Compliance is checked by inspection.

13.4 Screwed connections, which serve as electrical as well as mechanical connections, shall be locked against loosening or turning.

Compliance is checked by inspection and manual test.

NOTE — Spring washers may provide satisfactory locking. For rivets, a non-circular shank or an appropriate notch may be sufficient. Sealing compound which softens on heating provides satisfactory locking only for screw connections not subjected to torsion in normal use.

13.5 Current carrying parts, including those of terminals (also earthing terminals) Parts designed for carrying current including busbars, terminals and earthing terminals shall be of a material having, under the conditions occurring in the PT system, adequate mechanical strength and resistance to corrosion.

Compliance is checked by inspection and, if necessary, by chemical analysis.

Examples of suitable metals, when used within the permissible temperature range and under normal conditions of chemical pollution, are:

a) aluminium;

b) brass;

c) copper; and

d) an alloy containing at least 58 percent copper for parts that are worked cold, or at least 50 percent copper for other parts.

13.6 Live parts, which may be subjected to mechanical wear, shall not be made of steel provided with an electroplated coating.

For connection, an electroplated coating of zinc is permissible on parts which do not participate directly in current transmission, such as screws or washers used for certain types of terminals in which they transmit the contact pressure.

This requirement does not apply to contacts, magnetic circuits, heating elements, bimetallic components, shunts, parts of electronic devices, etc.

Compliance is checked by inspection.

14 MECHANICAL STRENGTH

14.1 General

When installed in accordance with the manufacturer's instructions, PT systems shall have adequate mechanical strength.

Compliance is checked by the tests according to **14.2** and **14.3**.

14.2 Impact Test

The test is performed on a sample of PT system according to IS 9000 (Part 7/Sec 7) using the pendulum hammer test Eha.

Any cover fixings and similar screws shall be tightened with the torque equal to the value declared by the manufacturer or, in the absence of this information, with the value according to Table 5.

The hammer is allowed to fall with an impact energy as declared by the manufacturer according to **7.1**.

A total of 10 blows shall be applied to points evenly distributed over the accessible surface of the enclosure, excluding knock-outs. Each point shall receive one blow only.

A new sample is then kept for 2 h in a refrigerator at the temperature of (-5 ± 1)°C. (10 ± 1) s after removal of the sample from the refrigerator the hammer is allowed to fall with an impact energy, as declared by the manufacturer according to **7.1**.

One blow shall be applied to the weakest point of the accessible surface of the enclosure, excluding knock-outs.

After the tests, the samples shall show no signs of disintegration and/or deformation that would impair continued safe operation. In particular:

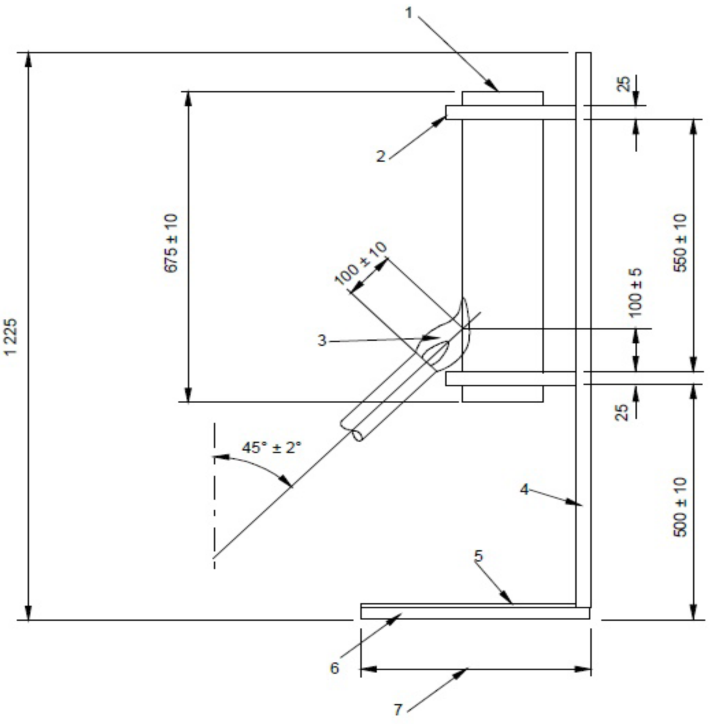
a) live parts shall not have become accessible;

b) the effectiveness of insulating linings and barriers shall not have been impaired; and

c) it shall be possible to remove and to replace external covers without these covers or their insulating linings breaking.

Damage to the finish, small dents which do not reduce the creepage distances or clearances below the values specified in **10** and small chips which do not adversely affect the protection against electric shock are neglected.

Cracks not visible with normal or corrected vision without additional magnification, and surface cracks in fibre-reinforced mouldings and the like are ignored.



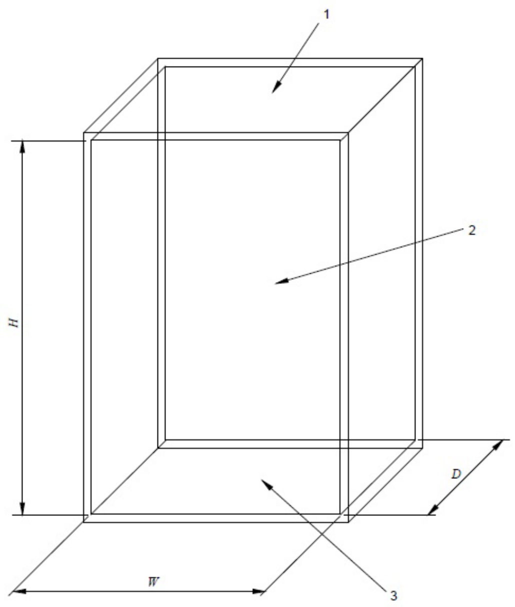
Key

1 Sample centrally located in the horizontal plane
2 Clamp
3 Flame
4 Back face
5 Wrapping tissue
6 10 mm soft white-wood board of width 700$_{-25}^{0}$
7 Depth of 450$_{-25}^{0}$

Dimensions in millimetres.

NOTE — this drawing is not intended to govern design except as regards the dimensions and specific requirements shown.

Fig. 3 Arrangement for flame Test



Key

1 Top surface
2 Back surface
3 Bottom surface
D Interior depth of enclosure 450$^{+25}_{0}$
H Interior height of enclosure 1 300 ± 25
W Interior width of enclosure 700$^{+25}_{0}$
Material: metal

Dimensions in millimetres.

NOTE — This drawing is not intended to govern design except as regards the dimensions and specific requirements shown.

Fig. 4 Enclosure for Flame Test

14.3 Static Load Test

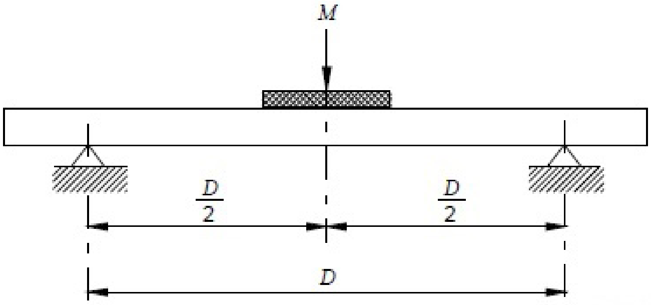
14.3.1 The static load test for a length shall be made on one straight length of PT system, which is supported as in normal use at two positions spaced at the distance *D*. This distance *D* shall be the maximum distance between supports declared by the manufacturer as shown in Fig 5. The location and form of the supports are also to be declared by the manufacturer.

A mass *M* shall be placed without dynamic loading on a square rigid piece with sides equal to the width of the system, at the midpoint between the supports on top of the enclosure. The mass *M* shall be equal to the mass *m* of that part of the system which is between the supports plus an additional mass *mL* equal to the maximum load imposed by the accessories to be connected to the length *D*.

The duration of the test shall be $(300\,^{+15}_{\;0})$ s.

14.3.2 The static load test for a joint shall be made on two straight lengths of PT system joined together and supported as in normal use at the minimum number of positions at the maximum distances *D* and D_1. The distance *D* is that specified in **14.3.1**, the distance D_1 is the maximum distance between supports adjacent to a joint as declared by the manufacturer. The joint shall be placed midway between the supports as shown in Fig. 6.

A mass M_1 shall be placed without dynamic loading on top of the enclosure at the joint on a square rigid piece with sides equal to the width of the system. The mass M_1 shall be equal to the mass m_1 of those parts of the system, including the joint between the supports located at distance D_1, plus an additional mass mL_1



Key

D maximum distance between supports declared by the manufacturer

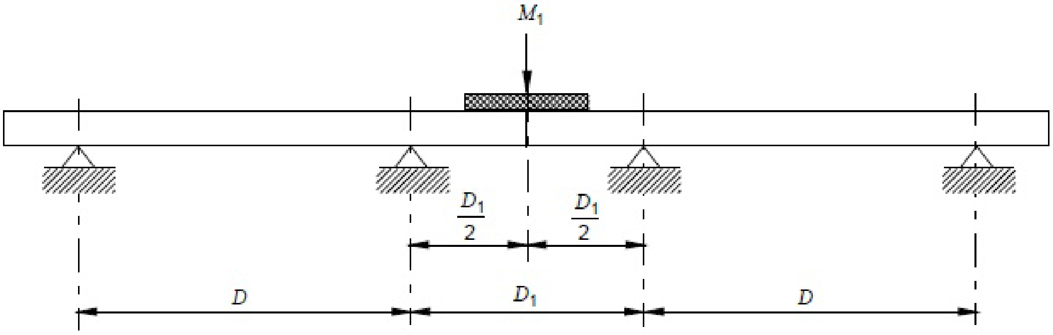
$M = m + mL$

where

m is the mass of the PT system between supports, and

mL is the mass of the accessories.

FIG. 5 STATIC LOAD TEST FOR A LENGTH



Key

D maximum distance between supports declared by the manufacturer

D_1 maximum distance between supports adjacent to a joint as declared by the manufacturer

$M_1 = m1 + mL_1$

where

m_1 is the mass of the PT system between supports located at distance D_1, and mL_1 is the mass of the accessories to be connected to the length D_1.

FIG. 6 STATIC LOAD TEST FFOR A JOINT

equal to the maximum load imposed by the accessories to be connected to the length D_1.

The duration of the test shall be $(300\ ^{+15}_{\ 0})$ s.

14.3.3 During the tests of **14.3.1** and **14.3.2**, the sample shall not break.

After the test:

a) the sample shall comply with **10** and **11.1**;

b) there shall be no permanent deformation which would prevent the correct insertion and withdrawal of the tap-off units; and

c) the samples shall withstand the test according to **15.3** but without the pre-conditioning of **15.2**, and the tests of **11.3**.

15 INSULATION RESISTANCE TEST AND DIELECTRIC STRENGTH TEST

15.1 General

Immediately after the humidity treatment according to **15.2** the insulation resistance test is carried out according to **15.3** and dielectric strength test according to **15.4**.

For **15.2, 15.3** and **15.4** a representative combination of system components typifying the PT system as a whole shall be assembled as in normal use. Electronic devices and accessories which are covered by their own standards or which may be damaged by the test shall be removed or disconnected before the tests.

The test voltage according to **15.3** and **15.4** is applied in the case of:

a) *Functional Insulation* — Between live parts of a PT system.

b) *Basic Insulation* — Between all live parts connected together and a metal foil covering the outer surface of the basic insulation and/or accessible metal parts in contact with the basic insulation.

c) *Supplementary Insulation* — Between two metal foils covering separately the inner, normally inaccessible surface, of the supplementary insulation and its accessible surface

d) *Reinforced Insulation* — Between all live parts connected together and a metal foil covering the accessible surface of the reinforced insulation.

The foils are not pressed into openings but are pushed into corners and the like by means of the test probe 11 of IS 1401.

Care shall be taken to insure that the clearances and creepage distances are maintained.

In case where basic insulation and supplementary insulation cannot be tested separately, the insulation provided is subjected to the test voltages specified for reinforced insulation.

15.2 Humidity Treatment

The humidity treatment shall be carried out in a humidity cabinet with a relative humidity T between 91 percent and 95 percent at a temperature maintained within ± 1 °C of any convenient value between 20°C and 30°C.

Before being placed in the humidity cabinet, the sample is brought to a temperature of $(T\ ^{+4}_{\ 0})$ °C.

Inlet openings, if any, are left open; if knockouts are provided one of them is opened.

The samples shall be kept in the cabinet for (96 ± 1) h.

NOTES:

1 In most cases samples may be brought to the chosen temperature of $(T\ ^{+4}_{\ 0})$ °C by keeping them at this temperature for at least 4 h before the humidity treatment.

2 A relative humidity of between 91 percent and 95 percent can be obtained by placing in the humidity cabinet a saturated solution of potassium nitrate (KNO_3) or sodium sulphate (Na_2SO_4) in water having a sufficiently large contact surface with the air. In order to achieve the specified conditions within the cabinet, it is necessary to ensure constant circulation of the air with the cabinet and, in general, to use a cabinet which is thermally insulated.

15.3 Insulation Resistance Test

15.3.1 *General*

The insulation resistance of the sample is measured with an applied d.c. voltage of $(500\ ^{+250}_{\ \ 0})$ V, the measurement being made $(60\ ^{+10}_{\ 0})$ s after application of the voltage.

15.3.2 *Test for Functional Insulation*

The insulation resistance value is taken as the recorded value multiplied by the sample length in metres.

The insulation resistance shall not be less than 2 MΩ/m.

15.3.3 *Test for Basic Insulation, Supplementary Insulation and Reinforced Insulation*

The insulation resistance shall not be less than the values given in Table 6.

Table 6 Minimum Insulation Resistance

(*Clause* 15.3.3)

Sl No.	Insulation to be Tested	Insulation Resistance MΩ
(1)	(2)	(3)
i)	Basic	2
ii)	Supplementary	5
iii)	Reinforced	7

NOTE — Materials, such as glazed ceramic or porcelain are considered to have adequate insulation resistance and are not subjected to the insulation resistance tests.

15.4 Dielectric Strength Test

The sample is subjected to a voltage of substantially sine wave form, having a nominal frequency 50 Hz. The voltage is applied for (5^{+1}_{0}) s across the insulation as given in Table 7.

Initially, not more than half the specified voltage is applied, then it is raised rapidly to the full value. No flashover or breakdown shall occur. Glow discharges without drop in voltage are neglected.

16 NORMAL OPERATION

16.1 For standardised plugs and socket-outlets, no additional requirements are specified in this standard. They shall comply with the relevant parts of their own national or international standard.

16.2 Plugs and socket-outlets other than those specified in **16.1** shall comply with the requirements of the relevant clauses of IS 1293.

No additional requirements are specified in this standard.

16.3 The connection of the tap-off unit with the powertrack shall withstand, without excessive wear or harmful effects, the electrical and mechanical stresses occurring in normal use.

Compliance is checked by the following test.

Tap-off units are inserted and withdrawn from the powertrack as in normal use.

An operation is either the insertion or withdrawal of a tap-off unit with the making or breaking of an electrical contact at a speed, which corresponds to practical use.

Tap-off units are tested with 100 operations, whereby after each 10 operations, the tap-off unit is moved to a new position on the powertrack. If there are less than 10 positions, the 100 operations are divided equally over the available number of positions.

a) for tap-off units classified according to **7.2.1** without voltage;
b) for tap-off units classified according to **7.2.2** with the rated voltage and without current; and
c) for tap-off units classified according to **7.2.3** with the rated voltage and rated current of the tap-off unit with power factor cos $\phi = 0.8 \pm 0.05$.

During the test, no sustained arcing shall occur.

After the test, the samples shall show no damage which would lead to non-compliance with this standard.

Compliance is checked by inspection and shall meet the requirements of **17.**

Table 7 Dielectric Strength

(*Clause* 15.4)

Sl No.	Insulation or Disconnection to be Tested b	Test Voltage (r.m.s.) [a]		
		Rated Voltage up to and Including 50 V V	Rated Voltage Above 50 V up to and Including 130 V V	Rated Voltage Above 130 V up to and Including 480 V V
(1)	(2)	(3)	(4)	(5)
i)	Functional insulation [c]	500	1 300	1 500
ii)	Basic insulation [d]	500	1 300	1 500
iii)	Supplementary insulation [d]		1 300	1 500
iv)	Reinforced insulation [d e]	500	2 600	3 000

NOTES:

1 Up to 50 V: not intended to be connected directly to the mains and not expected to be subjected to temporary overvoltages as defined in IEC 60364-4-44.

2 Over 50 V: the values are based on IEC 60364-4-44.

3 for functional, basic and supplementary insulation, the values are calculated with the formula U_o + 1 200 V and rounded. In this standard the maximum voltage considered between line and earth is U_o = 300 V.

[a] The high-voltage transformer used for the test shall be designed so that, when the output terminals are short-circuited after the output voltage has been adjusted to the test voltage, the output current is at least 200 mA. The overcurrent relay shall not trip when the output current is less than 100 mA. Care is taken that the r.m.s value of the test voltage is measured within ± 3 percent.

[b] Special components which might render the test impractical such as discharge lamps, coils, windings, or capacitors are disconnected at one pole, or bridged, as appropriate to the insulation being tested.

[c] An example is the insulation between poles.

[d] For the test all live parts are connected together and care is taken to ensure that all moving parts are in the most onerous position.

[e] For PT systems incorporating reinforced insulation as well as double insulation, care is taken that the voltage applied to the reinforced insulation does not overstress the basic or the supplementary parts of the double insulation.

17 TEMPERATURE RISE

17.1 PT systems shall be so designed and constructed that when installed and carrying rated current as in normal use the temperature rise shall not be excessive.

Compliance is checked by the tests of **17.2, 17.3** and **17.4**.

For the temperature rise test of terminals for external conductors, insulated copper conductors according to Table 9 or Table 10 shall be used.

Where the rated connecting capacity of the terminal cannot accommodate the test conductors in Table 9 or Table 10, then test conductors having a cross-sectional area according to Table 4 shall be used.

The PT system shall be placed in a draught free environment and the rated current passed until thermal equilibrium is reached. Thermal equilibrium is taken as less than 1 K rise within 1 h.

The temperature rise is the difference in temperature between the part under test and the surrounding ambient air temperature. The ambient air temperature shall be measured during the last quarter of the test period by at least two temperature means equally distributed around the PT system at approximately half its height and at a distance of approximately 1 m from the part under test. The temperature measurement means shall be protected against air currents and heat radiation.

The ambient air temperature shall be maintained in accordance with **5.2**.

Temperature rise values shall be recorded and shall not exceed the values in Table 8.

If similar PT systems exist, then only the PT system likely to produce the highest temperature rise shall be tested. PT systems can be considered similar if they have the same basic design, in particular all of the following features:

a) the same rated current;
b) the materials, finish and dimensions of the internal current carrying parts are identical;
c) the moulding, insulating and enclosure materials/ dimensions are identical; and
d) the methods of connection are identical.

Fused and unfused systems components are not considered to be similar.

17.2 A convenient voltage is applied to the incoming supply terminals of the PT system and connecting electrical loads at the other end of the PT system or via appropriate plugs or tap-off units mounted as near as practicable to that end. The test shall be performed over a total length of at least 6 m including at least one joint. The test current shall be equal to the rated current.

17.3 A temperature rise test shall be made on each size of unfused tap-off unit designed to be connected to the PT system. For this test, the tap-off unit shall be mounted as near as practicable to the incoming supply terminals at the closest spacing declared by the manufacturer and carry the test current. The PT system shall be supplied with its rated current.

17.4 A temperature rise test shall be made on each size of fused tap-off unit designed to be connected to the PT system. For this test, the tap-off unit shall be mounted as near as practicable to the incoming supply terminals at the closest spacing declared by the manufacturer and carry the test current. The PT system shall be supplied with its rated current. The fuse shall be replaced by a dummy fuse-link of maximum wattage as defined in

a) IS/IEC 60127-1,
b) IEC 60269-1, or
c) as declared by the manufacturer of the PT system if the fuse is not in accordance with IS/IEC 60127-1 or IEC 60269-1.

18 SHORT-CIRCUIT PROTECTION AND SHORT- CIRCUIT WITHSTAND STRENGTH

18.1 General

PT systems shall be so constructed as to be capable of withstanding the thermal and dynamic stresses resulting from short-circuit currents up to the rated values.

Compliance is checked by the tests in **18.4**.

The tests may be carried out in any order and on one sample, or each test may be carried out on a new sample at the manufacturer's discretion.

18.2 Information Concerning Short-Circuit Rating

18.2.1 The manufacturer shall state the short-circuit ratings of the PT system as follows.

18.2.2 For a PT system with a short-circuit protective device (SCPD) located at the supply connector, the manufacturer shall declare the maximum allowable value of prospective short-circuit current at the terminals of the supply connector. The test parameters shall be those shown in Table 11.

The manufacturer shall state the characteristics of the SCPD (current rating, breaking capacity, cut-off current, I^2t, etc.).

18.2.3 For a PT system where the short-circuit protective device is not located at the supply connector, the manufacturer shall declare one or more of the following:

a) the rated conditional short-circuit current and the characteristics of the protective device necessary for the protection of the PT system; and
b) the rated short time withstand current of the PT system.

Table 8 Temperature Rise Values

(*Clause* 17.1)

Sl No.	Parts of the PT System	Temperature Rise K
(1)	(2)	(3)
i)	Terminals for accessories	For accessories the temperature rise of terminals shall be in accordance with the relevant accessory standard.
ii)	Terminals which will influence accessories	Terminals of system components in the vicinity of and likely to influence accessories shall be in accordance with the temperature rise limits of the relevant accessory standard.
iii)	Built-in components[a]	In accordance with the relevant requirements for the individual components, if any, or, as declared by the manufacturer, taking into consideration the temperature in the PT system.
iv)	Terminals for external conductors	55
	Conductors, internal terminals, terminations, tap- off units and plug-in contacts of removable or withdrawable parts which connect to conductors	Limited by a) mechanical strength of conducting material; b) possible effect on adjacent equipment; c) permissible temperature limit of the insulating materials in contact with the conductor; and d) the effect of the temperature of the conductor on the apparatus connected to it; a) for plug in contacts, nature and surface; b) treatment of the contact material.
v)	Manual operating means of system components	
	a) of metal	25
	b) of insulating material	35
vi)	Accessible external enclosures and covers of system components:	
	a) metal surfaces	30 [b]
	b) insulating surfaces	40 [b]

[a] The term “built-in components” means:

a) conventional switchgear and controlgear;

b) electronic sub-assemblies (for example, rectifier bridge, printed circuit); and

c) parts of the equipment (for example, regulators, stabilised power supply unit, operational amplifier).

[b] For surfaces which are accessible but need not be touched during normal operation,p such as PT systems mounted underfloor or fixed to the ceiling, an increase in the temperature-rise limits by 10 K is permissible.

Table 9 Cross-sectional Areas of Rigid Test Conductors (Solid or Stranded)

(*Clause* 17.1)

Sl No.	Rated Current of System A	Cross-sectional Areas of Rigid Test Conductors mm^2
(1)	(2)	(3)
i)	Up to and including 10	1.5
ii)	Over 10 and up to and including 16	2.5
iii)	Over 16 and up to and including 20	4
iv)	Over 20 and up to and including 32	6
v)	Over 32 and up to and including 45	10
vi)	Over 45 and up to and including 63	16

Table 10 Cross-sectional Areas of Flexible Test Conductors

(*Clause* 17.1)

Sl No.	Rated Current of Accessory A	Cross-sectional Areas of Flexible Test Conductors mm^2
(1)	(2)	(3)
i)	Up to and including 3	0.50
ii)	Over 3 and up to and including 6	0.75
iii)	Over 6 and up to and including 10	1.0
iv)	Over 10 and up to and including 13	1.25
v)	Over 13 and up to and including 16	1.5
vi)	Over 16 and up to and including 20	2.5
vii)	Over 20 and up to and including 32	4

18.2.4 The declared short-circuit rating of a tap-off unit not incorporating a SCPD shall be the same as the manufacturer's declaration for the PT system according to **18.2.2** or **18.2.3**.

18.2.5 The declared short-circuit rating of a tap-off unit incorporating a SCPD shall be declared by the manufacturer and may be the same or less than the value declared for the PT system according to **18.2.2** or **18.2.3**.

18.2.6 The declared short-circuit rating of a tap -off unit without a SCPD and which incorporates a socket-outlet that only accepts a fused plug shall be not less than the breaking capacity of the largest fuse that can be accommodated in the plug.

18.2.7 The declared short-circuit rating of a tap-off unit without a SCPD and which incorporates a socket-outlet that only accepts an un-fused plug, the short-circuit rating shall be as per the manufacturer's declaration for the PT system according to **18.2.2** or **18.2.3**.

18.3 Short Circuit Current Values

18.3.1 Relationship between Peak Current and Short-Circuit Current

For determining the electrodynamic stresses, the value of peak current shall be obtained by multiplying the short-circuit current by the factor *n*. Standard values for the factor *n* and the corresponding power factor are given in Table 11.

Table 11 Standard Values for the Factor *n*

(*Clause* 18.3.1)

Sl No.	I_{rms} Value of Short-circuit Current kA	cos ϕ	*n*
(1)	(2)	(3)	(4)
i)	$I \leq 5$	0.7	1.5
ii)	$5 < I \leq 10$	0.5	1.7
iii)	$10 < I \leq 20$	0.3	2
iv)	$20 < I \leq 50$	0.25	2.1

NOTE — Values of this table represent the majority of applications. In special locations, for example, in the vicinity of transformers or generators, lower values of power factor may be found, whereby the maximum prospective peak current may become the limiting value instead of the r.m.s. value of the short-circuit current.

18.3.2 Value and Duration of the Short-circuit Current

a) For PT system protected by short-circuit protective devices, whether these devices are in the incoming circuit or elsewhere, the test voltage shall be applied for a time of sufficient duration to enable the short-circuit protective devices to operate to clear the fault and, in any case, for not less than 10 full cycles of the supply frequency.

b) PT system which do not incorporate a short-circuit protective device in the incoming unit (*see* **18.2.3**).

18.4 Verification of Short-Circuit Withstand Strength

18.4.1 *Test Arrangement*

A typical PT system including at least one joint shall be set up as in normal use to obtain a conductor length of not more than 6 m. Components of the system not included in the test shall be tested separately, assembled in a manner representative of service conditions.

18.4.2 *Test Conditions — General*

If the test circuit incorporates SCPDs, then they shall be rated for the maximum current of the powertrack and/ or tap-off unit as applicable and be of the type specified by the manufacturer.

The supply conductors and the short-circuit connections required for testing the PT system shall be as defined in **17** and Fig. 7. Unless otherwise agreed, the test circuit shall be connected to the terminals of the supply connector. Three-phase PT systems shall be connected on a three-phase basis.

For the verification of the short-circuit withstand rating, the value of the prospective short-circuit current at a supply voltage equal to 1.05 times the rated operational voltage shall be determined from a calibration oscillogram. The position of the calibration short circuit shall be at point 3 shown in Fig. 7. The oscillogram shall show that there is a constant flow of current such that it is measurable at a time at least equivalent to the operation of the protective device incorporated in the PT system or for a specified period of time.

The frequency of the test circuit during the short-circuit tests shall be that of the rated frequency subject to a tolerance of ± 25 percent.

All parts of the equipment intended to be connected to the protective conductor in service, including the enclosure, shall be connected as follows:

a) for PT system suitable for use on three-phase four-wire systems (*see* also IS 12360) with an earthed star point and marked accordingly, to the neutral point of supply or to a substantially inductive artificial neutral permitting a prospective fault current of at least 50 A; and

b) for PT system also suitable for use in three-phase three-wire as well as on three-phase four-wire systems and marked accordingly, to the phase conductor least likely to arc to earth.

The test circuit shall include a reliable device (for example, a fuse of copper wire of 0.1 mm in diameter and not less than 50 mm in length) for the detection of the fault current. The prospective fault current in the fuse element circuit shall be at least 50 A.

NOTE — A copper wire of 0.1 mm in diameter will melt at 50 A, in approximately half a cycle, at a frequency between 45 Hz and 67 Hz (or 0.01 s for d.c.).

For testing the protective circuit, the frame of the PT system shall be insulated from earth.

The test voltage shall be equal to the single-phase value of the rated operational voltage.

18.4.3 *Testing of the PT System*

18.4.3.1 *General*

The following tests shall be performed as described in **18.4.1** and **18.4.2**.

18.4.3.2 *Busbar testing*

Three phase or single phase system.

The following tests are applicable to establish:

a) the rated conditional short-circuit current I_{CC}, or
b) the rated short-time withstand current (I_{CW}).

For a single phase system the PT system shall be tested by applying a short circuit between the line and neutral at the end of the busbars, as generally illustrated in Fig. 7.

For a three phase system the PT system shall be tested by applying a short circuit between all three phases at the end of the busbars, as generally illustrated in Fig. 7.

For a three-phase system with a neutral, the neutral busbar shall additionally be subjected to a test to prove its short-circuiting performance in relation to the nearest phase busbar. The value of the test current in the neutral busbar shall be at least 60 percent of the value of the three phase prospective short circuit current.

The protective earth conductor shall be subjected to a test to prove its short-circuit performance in relation to the nearest phase busbar. The value of the test current in the PE conductor shall be equal to the single phase prospective short-circuit current for single phase systems or at least 60 percent of the value of the three phase prospective short circuit current for three phase systems.

Prior to testing the protective earth circuit it shall be verified that the different exposed conductive parts of the PT system are effectively connected to the protective circuit.

Compliance is checked by inspection.

A single-phase test supply shall be connected to the incoming terminal of one phase and to the terminal for the incoming protective conductor. When the PT system is provided with a separate protective conductor, the nearest phase conductor shall be used. The short circuit shall be applied between the protective conductor and the phase conductor at the end of the busbars, as generally illustrated in Fig. 7.

After the test the function of the protective circuit shall not be significantly impaired.

Compliance is checked by the test of **11.3.1** but on the sample arrangement determined by **18.4.1**.

Where the casing is used as a protective conductor, sparks and localized heating at joints are permitted, provided they do not impair the electrical continuity and provided that adjacent flammable parts are not ignited.

After the short circuit tests the PT system shall not show any deformation which affects creepage and clearance distances. In case of doubt the PT system shall be checked in accordance with **10.2** and **10.3**. Slight deformation of the busbars is acceptable provided that the deformation does not interfere with the proper connection of tap-off units. In case of doubt the tap-off unit shall be checked in accordance with **16.3**.

The insulation of the conductors and the supporting insulating parts shall not show any significant signs of deterioration.

Compliance is checked with 15.4 at 85 percent of the test voltage given in Table 7 with all fuses replaced and with all switching devices closed if applicable.

18.4.3.3 *Tap-off unit testing*

Three phase or single phase system.

The following tests are applicable to establish:

a) the rated conditional short-circuit current I_{CC}, or
b) the rated short-time withstand current (I_{CW}).

Tap-off units shall be supplied by the manufacturer complete with cable of the required length and size.

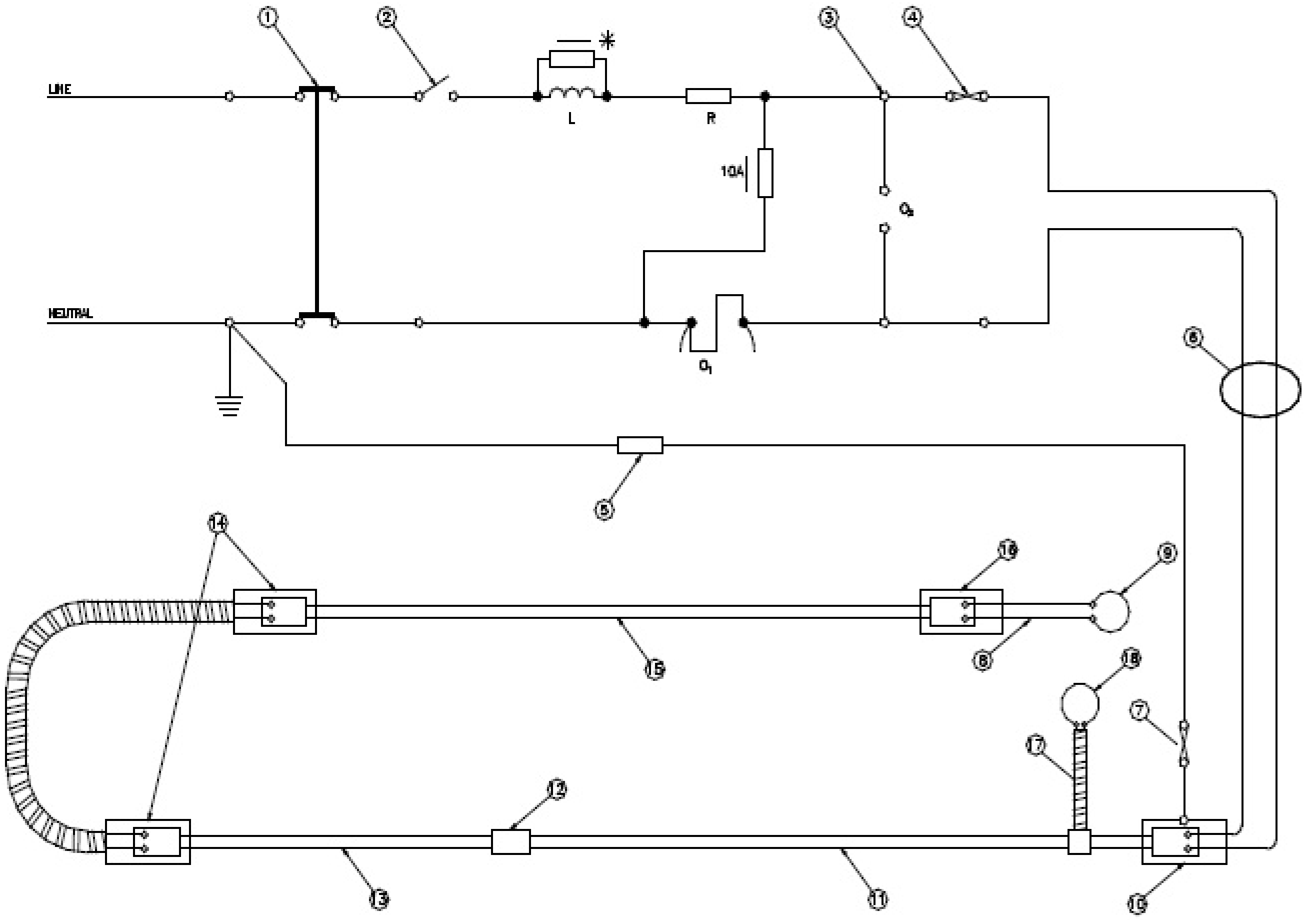
Tap-off units shall be positioned at the first available tap-off outlet position closest to the supply connector.

For tap-off units incorporating or not incorporating a SCPD, the position of the short -circuit shall be the shortest length ‘L’ as declared by the manufacturer, from the tap-off unit to the point of the short-circuit.

For tap-off units incorporating a socket-outlet, a plug is inserted with an attached cable length of not more than 300 mm, a short-circuit shall be applied to the end of the cable.

A single phase tap-off unit shall be tested by applying a short circuit between the line and neutral, as generally illustrated in Fig. 7.

A three phase tap-off unit shall be tested by applying a short circuit between all three phases as generally illustrated in Fig. 7.



Key

1. Circuit breaker
2. Closing switch
3. Calibration point
4. Protective device
5. Resistor to limit earth fault current to 100 A
6. 4.0 m of cable
7. Fine wire fuse 0.1 mm diameter × 50 mm long tinned copper wire
8. 0.6 m of cable
9. Shorting out connection (when testing busbar only, *see* **18.4.3.2**)
10. Supply connector
11. Length of track
12. Joint (separate or integral)
13. Length of track
14. Flexible corner or similar if applicable
15. Length of track
16. Supply connector
17. Tap-off unit
18. Shorting out connection (when testing tap-off units only, *see* **18.4.3.3**)

* The regulator is to take approximately 1 percent of the current through the inductor.

NOTE — O_1 and O_2 are oscillograph connections.

Fig. 7 Short-Circuit Test Arrangement

For a three-phase system with a neutral, the neutral conductor shall additionally be subjected to a test to prove its short-circuit performance in relation to the nearest phase conductor. The value of the test current in the neutral conductor shall be at least 60 percent of the value of the three phase prospective short circuit current.

The protective earth conductor shall be subjected to a test to prove its short-circuit performance in relation to the nearest phase, in the tap-off unit. The value of the test current in the PE conductor shall be equal to the single phase prospective short-circuit current for single phase systems or at least 60 percent of the value of the three phase prospective short circuit current for three phase systems.

Prior to testing the protective earth circuit it shall be verified that the different exposed conductive parts of the tap-off unit are effectively connected to the protective circuit.

Compliance is checked by inspection.

A single-phase test supply shall be connected to the incoming terminal of one phase and to the terminal for the incoming protective conductor. When the PT system is provided with a separate protective conductor, the nearest phase conductor shall be used.

After the test the function of the protective circuit shall not be significantly impaired.

Compliance is checked by the test of **11.3.2**.

Where the casing is used as a protective conductor, sparks and localized heating at joints are permitted, provided they do not impair the electrical continuity and provided that adjacent flammable parts are not ignited.

After the short circuit tests the tap-off unit shall not show any deformation which affects creepage and clearance distances. In case of doubt the tap-off unit shall be checked in accordance with **10.2** and **10.3**. Slight deformation of the contacts is acceptable provided that the deformation does not interfere with the proper connection of tap-off units. In case of doubt the tap-off unit shall be checked in accordance with **16.3** at its tested position and one other tap-off outlet position for 10 operations in each case.

NOTE — The risk of contact welding is recognised, in which case the manufacturer should indicate the measures to be taken regarding the maintenance of the equipment.

The insulation of the conductors and the supporting insulating parts shall not show any significant signs of deterioration.

Compliance is checked with 15.4 at 85 percent of the test voltage given in Table 7 with all fuses replaced and with all switching devices closed if applicable.

19 RESISTANCE TO HEAT

19.1 PT systems and system components shall be sufficiently resistant to heat.

Compliance is checked by the relevant tests of **19.2**, **19.3**, **19.4** and **19.5** except for insulating materials of ceramic or mica, which are not tested.

19.2 Parts of insulating material:

a) necessary to retain current-carrying parts in position, other than busbars; or
b) which maintain contact pressure shall be subjected to a ball pressure test according to IEC 60695-10-2.

The tests shall be made in a heating cabinet at the temperature rise value recorded during the test of **17.1**, plus (40 ± 2)°C or at (125 ± 2)°C whichever is the higher.

19.3 Parts of insulating material not necessary to retain live parts in position, even though they may be in contact with them, as well as parts of insulating material which are necessary to retain busbars in position shall be subjected to a ball pressure test according to **19.2** but the test shall be made at (40 ± 2)°C plus the temperature rise value recorded for those parts during the test of **17.1**, or at (70 ± 2)°C whichever is the highest.

If the manufacturer declares that the test for the insulating material retaining busbars in position shall be done according to **19.2**, then the test according to **19.3** and **19.4** for this material is not necessary.

19.4 The thermal endurance of insulating materials, necessary to retain busbars in position is tested as follows:

A representative combination of system components typifying the PT system as a whole shall be mounted as in normal use and kept for (96 ± 1) h in a heating cabinet at the busbar temperature rise value, recorded during the test of **17.1**, plus (40 ± 2) °C.

NOTE — For test purposes, components which cause mechanical stress to the busbars and the material which retains the busbars in position should be used. After the test, the insulating material necessary to retain busbars in position shall show no visible signs of deterioration or any shrinkage which would impair safety when inspected with normal or corrected vision without additional magnification.

19.5 The thermal endurance for all insulating materials other than those specified in **19.4** is tested as follows:

A representative combination of system components typifying the PT system as a whole shall be mounted as in normal use and kept for (96 ± 1) h in a heating cabinet at (60 ± 2)°C.

After the test, the insulating material shall show no visible signs of deterioration or any shrinkage, which would impair safety when inspected with normal or corrected vision without additional magnification.

20 FIRE HAZARD

20.1 Flammability

Parts of insulating material which might be exposed to thermal stresses due to electrical effects and the deterioration of which might impair the fire safety of the system, shall not be unduly affected by abnormal heat generated inside the PT system.

Compliance is checked by the following glow wire test according to **4** to **10** of IEC 60695-2-11 at the temperatures given in Table 12.

Table 12 Test Temperatures for the Glow Wire Test

(*Claus*e 20.1)

Sl No.	Parts of Insulating Material	Temperature of the Glow Wire (°C)
(1)	(2)	(3)
i)	Parts in contact with current-carrying parts and necessary to retain them in position	850 ± 15
ii)	All other parts, including parts not necessary to retain current-carrying parts in position	650 ± 10

For the purpose of this test a protective conductor (PE) is not to be considered as a current carrying part.

The test is made on one sample only. In case of doubt, the test shall be repeated on two further samples.

The tests are not made on parts of ceramic material or on small parts, such as washers or screws.

If the test has to be made at more than one place on the same part, care shall be taken to ensure that any deterioration caused by previous test(s) does not affect the result of the test to be made.

If possible, the sample shall be a complete system component. If the test cannot be made on a complete system component, a suitable part may be taken from it for the purpose of the test.

20.2 Flame Spread

PT systems shall not propagate flame.

Compliance is checked by the following test.

The test is made on a single straight length of powertrack as supplied by the manufacturer together with any covers. The overall length of the sample shall be (675 ± 10) mm.

The test is performed using the burner specified in IEC 60695-11-2.

The sample is placed vertically as shown in Fig. 3 in the middle of the open front face of a metal enclosure as shown in Fig. 4, in an area substantially free from draughts. It shall be clamped at both ends in order to prevent distortion or movement of the sample itself under flame conditions.

The burner is positioned in such a way that the axis forms an angle of (45 ± 2)° with the vertical one and the flame is in contact with the surface of the sample at an approximate distance of 100 mm from the upper extremity of the lower clamp which is (500 ± 10) mm above the internal lower surface of the enclosure.

The flame shall be applied to the largest surface which is exposed when the sample is mounted according to the manufacturer's instructions. The sample is exposed to the flame for 60 ± 2 s.

The sample is regarded as having passed the test if:

a) it does not ignite, or

b) in the case of ignition, the following three conditions are fulfilled:

  1) the flame extinguishes within 30 s after removal of the test flame;

  2) there is no ignition of the wrapping paper or scorching of the board; and

  3) after wiping of the sample, there is no evidence of burning or charring within 50 mm of the lower extremity of the upper clamp.

21 EXTERNAL INFLUENCES

21.1 Resistance to Corrosion

21.1.1 *General*

Ferrous parts shall be adequately protected against corrosion.

Compliance is checked by the tests in **21.1.2** and/or **21.1.3** on a sample of not less than 250 mm in length.

21.1.2 *Corrosion Test for Dry Non-Aggressive Environments*

All grease shall be removed from the sample to be tested by cleaning with white spirit with a kauri-butanol value of 35 ± 5 after which all parts shall then be dried.

The parts shall then be immersed for (10^{+1}_{0}) min in a 10 percent solution of ammonium chloride in water at a temperature of (20 ± 5)°C.

Without drying, but shaking off any drops, the parts shall then be placed for (10^{+1}_{0}) min in a box containing air saturated with moisture at a temperature of (20 ± 5)°C. After the parts have been dried for 10 min in a heating cabinet at a temperature of (100 ± 5)°C, any traces of rust on sharp edges and yellowish film may be removed by rubbing, after which their surfaces shall show no signs of rust.

NOTE — For small helical springs and the like, and for parts exposed to abrasion, a layer of grease may provide sufficient protection against rusting. Such parts are subjected to the test only if there is a doubt about the effectiveness of the grease film and the test is then carried out without previous removal of the grease film.

21.1.3 *Corrosion Test for Powertrack in Contact With Wet Screed Material*

All grease shall be removed from the sample to be tested by cleaning with white spirit with a kauri-butanol value of 35 ± 5, after which all parts shall then be dried.

After exposure, the surface shall show no areas of red rust. White rust (zinc oxide) and traces of red rust which are removable by rubbing as well as traces of rust at the surface of cuts, bent edges and welded joints are ignored.

21.2 Degrees of Protection Provided by Enclosures

21.2.1 *General*

PT systems, when assembled and installed according to the manufacturer's instructions, shall provide adequate protection according to the classification of **7.3** declared by the manufacturer.

Compliance is checked by the tests of **21.2.2** and **21.2.3**.

Tests are performed on an assembly or assemblies each made of representative parts of the PT system.

21.2.2 *Protection against Ingress of Solid Foreign Objects*

An assembly is tested in accordance with the appropriate test of IS/IEC 60529. For numeral 5, category 2 applies.

The assembly tested for numeral 5 or 6 passes the test if there is no ingress of dust visible to normal or corrected vision without additional magnification.

21.2.3 *Protection against Ingress of Water*

The assembly is tested in accordance with the appropriate test of IS/IEC 60529. For numerals 3 and 4, the spray nozzle according to Fig. 5 of that standard is used.

The assembly tested above passes the test if there is no ingress of water in a quantity that would interfere with the correct operation of the PT system or impair safety which is checked by the test according to **15.4** but without prior humidity treatment according to **15.2**.

22 ELECTROMAGNETIC COMPATIBILITY

22.1 Immunity

Products covered by this standard are tolerant of electromagnetic disturbances and therefore no immunity tests are necessary.

22.2 Emission

Electromagnetic disturbances may only be generated during switching operations or by electronic circuits, therefore no emission tests are necessary.

ANNEX A

(*Normative*)

MEASUREMENT OF CLEARANCES AND CREEPAGE DISTANCES

The width *X* shown in examples 1 to 11 below apply to all examples as a function of the pollution degree as given in Table A-1.

Table A-1 Minimum Values of Width X
Pollution Degree Minimum Values of Width X

Sl No.	Pollution Degree	Minimum Values of Width X Mm
(1)	(2)	(3)
i)	1	0.25
ii)	2	1.0
iii)	3	1.5

If the associated clearance is less than 3 mm, the minimum groove width *X* may be reduced to one-third of this clearance.

The methods of measuring creepage distances and clearances are indicated in the following examples 1 to 11. These cases do not differentiate between gaps and grooves or between types of insulation.

The following assumptions are made:

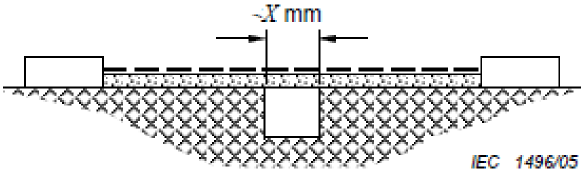
a) any recess is assumed to be bridged with an insulating link having a length equal to the width *X* and being placed in the most unfavourable position (*see* example 3);

b) where the distance across a groove is equal to or larger than the width *X*, the creepage distance is measured along the contours of the groove (*see* example 2);

c) creepage distances and clearances measured between parts which can assume different positions in relation to each other are measured when these parts are in their most unfavourable position.

Explanation for examples 1 to 11

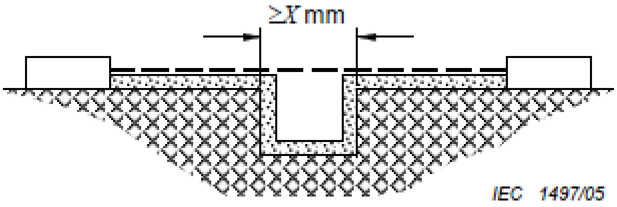
- - - - -	Clearance
▨	Creepage distance



Example 1

Condition: Path under consideration includes a parallel or converging-sided groove of any depth with a width less than *X* mm.

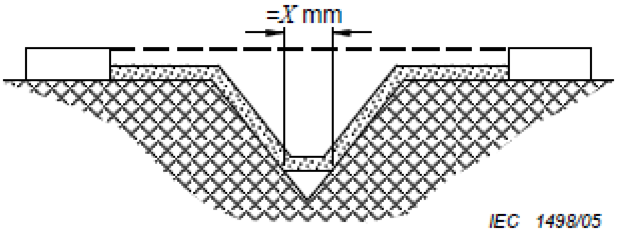
Rule: Creepage distance and clearance are measured directly across the groove as shown.



Example 2

Condition: Path under consideration includes a parallel-sided groove of any depth and with a width equal to or more than *X* mm.

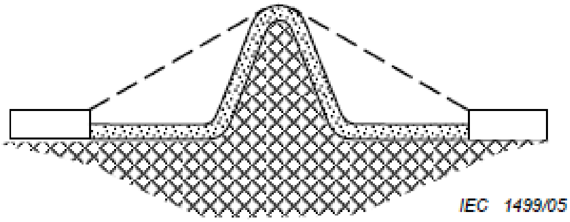
Rule: Clearance is the “line of sight” distance. Creepage path follows the contour of the groove.



Example 3

Condition: Path under consideration includes a V-shaped groove with a width greater than *X* mm.

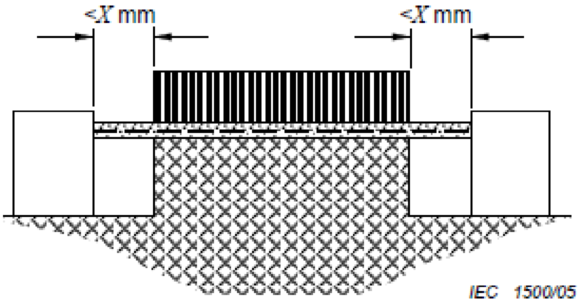
Rule: Clearance is the “line of sight” distance. Creepage path follows the contour of the groove but “short-circuits” the bottom of the groove by an *X* mm link.



Example 4

Condition: Path under consideration includes a rib.

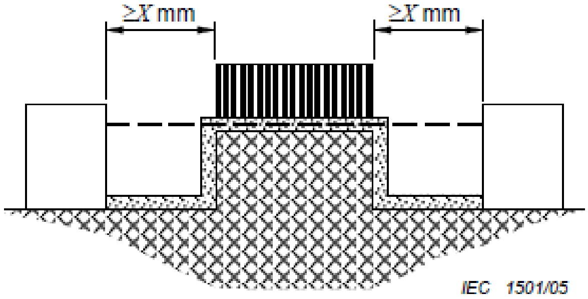
Rule: Clearance is the shortest direct air path over the top of the rib. Creepage path follows the contour of the rib.



Example 5

Condition: Path under consideration includes an uncemented joint with grooves less than X mm wide on each side.

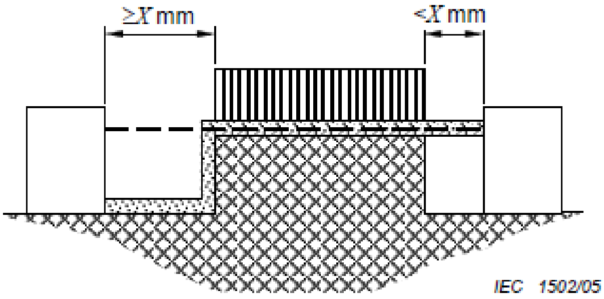
Rule: Clearance path is the "line of sight" distance. Creepage follows the contour of the grooves.



Example 6

Condition: Path under consideration includes an uncemented joint with grooves equal to or more than X mm wide on each side.

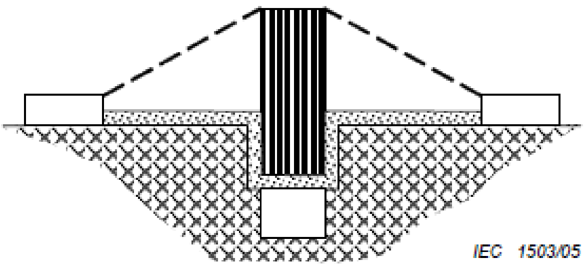
Rule: Clearance path is the "line of sight" distance. Creepage follows the contour of the grooves.



Example 7

Condition: Path under consideration includes an uncemented joint with groove on one side less than X mm wide and the groove on the other side equal to or more than X mm wide.

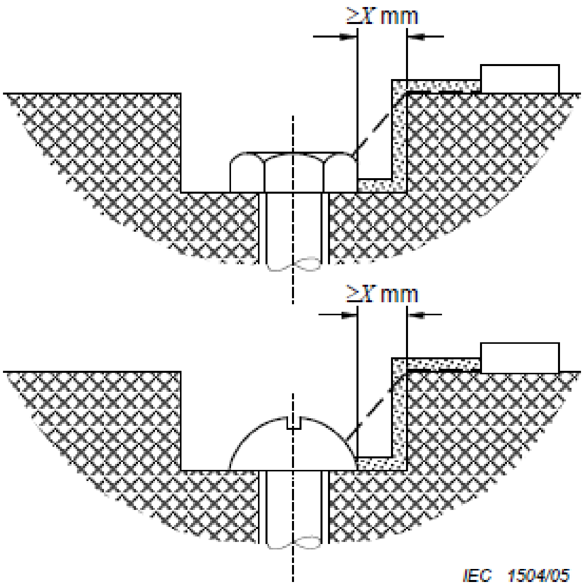
Rule: Clearance and creepage paths are as shown.



Example 8

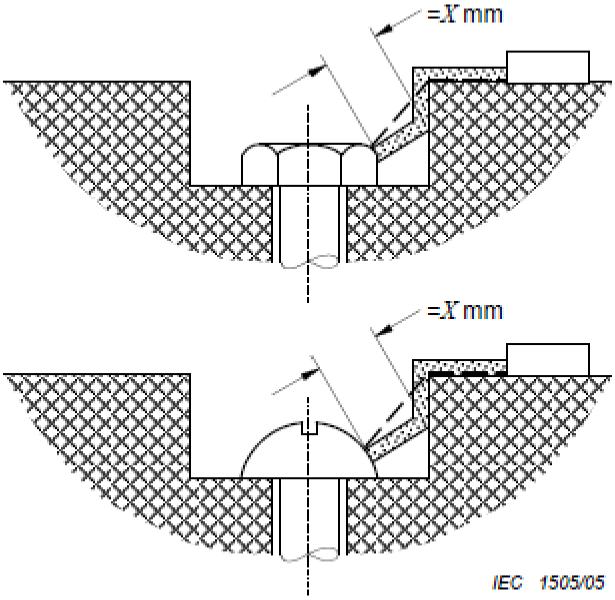
Condition: Creepage distance through uncemented joint is less than creepage distance over barrier.

Rule: Clearance is the shortest direct air path over the top of the barrier. The creepage path follows the contour of the joint.



Example 9

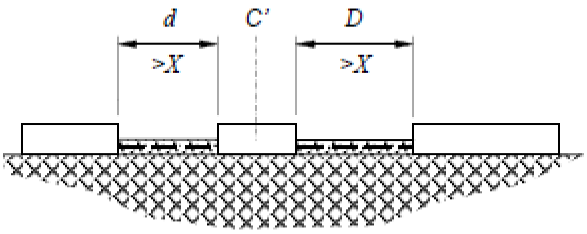
Gap between head of screw and wall of recess wide enough to be taken into account.



Example 10

Gap between head of screw and wall of recess too narrow to be taken into account.

Measurement of creepage distance is from screw to wall when the distance is equal to X mm.



Example 11

Clearance is distance ($d + D$)

Creepage distance is also ($d + D$)

ANNEX B

(*Normative*)

PROOF TRACKING TEST

The proof tracking test is made in accordance with IS 2824.

For the purpose of this standard, the following applies.

a) In clause **5**, test sample, of IS 2824:
   1) note 3 also applies to the proof-tracking index procedure of **10.1**; or
   2) if the surface 15 mm × 15 mm cannot be obtained because of the small dimension of the PT systems, special samples made with the same manufacturing process shall be used.

b) In **7.3**, Test solutions, of IS 2824, test solution “A” shall be used.

c) The proof-tracking index procedure of **10.1** of IS 2824 is performed on 3 samples at the voltage related to the PTI value for the material group declared by the manufacturer according to **10.3** of this standard.

ANNEX C

(*Normative*)

RELATIONSHIP BETWEEN RATED IMPULSE WITHSTAND VOLTAGE, RATED VOLTAGE AND OVERVOLTAGE CATEGORY III

Table C-1 Rated Impulse Withstand Voltage for PT Systems Energised Directly from the Low Voltage Mains

Sl No.	**Nominal Voltage of the Supply System based on IEC 60038**[a] V		**Voltage Line to Neutral Derived from Nominal Voltages a.c. or d.c. up to and Including** V	**Rated Impulse Withstand Voltage** V
	Three Phase	Single Phase		Overvoltage Category
(1)	(2)	(3)	(4)	(5)
i)	230/400	120-240	50	800
ii)			100	1500
iii)			150	2500
iv)			300	4000
v)			600[b]	6000[b]

NOTES:

1 For more information concerning supply systems, *see* IEC 60664-1 Annex B.

2 For more information concerning overvoltage category, *see* **4.3.3.2.2** of IEC 60664-1.

[a] The / mark indicates a four-wire three-phase distribution system. The lower value is the voltage line-to-neutral, while the higher value is the voltage line-to-line.

[b] These values are outside the scope of this standard.

c These values are included to allow use with **10.2.5**.

ANNEX D

(*Normative*)

POLLUTION DEGREE

D-1 INTRODUCTION

The micro-environment determines the effect of pollution on the insulation. The macroenvironment, however, has to be taken into account when considering the micro-environment.

Means may be provided to reduce pollution at the insulation under consideration by effective use of enclosures, encapsulation or hermetic sealing. Such means to reduce pollution may not be effective when the PT system is subject to condensation or if, in normal operation, it generates pollutants itself.

Small clearances can be bridged completely by solid particles, dust and water and therefore minimum clearances are specified where pollution may be present in the micro-environment.

NOTE — Pollution will become conductive in the presence of humidity. Pollution caused by contaminated water, soot, metal or carbon dust is inherently conductive.

D-2 DEGREES OF POLLUTION IN THE MICRO-ENVIRONMENT

For the purpose of evaluating creepage distances and clearances, the following three degrees of pollution in the micro-environment are established:

D-2.1 Pollution Degree 1

No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

D-2.2 Pollution Degree 2

Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.

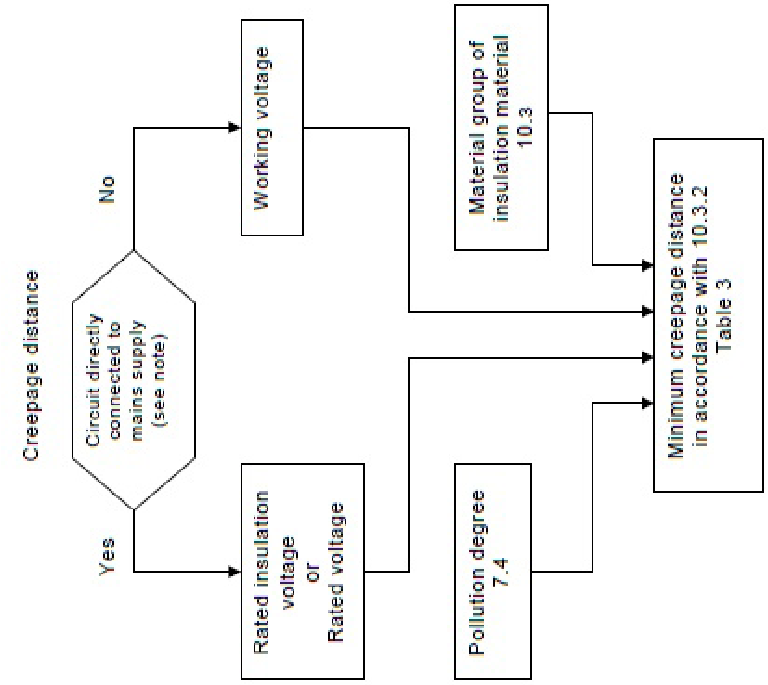
D-2.3 Pollution Degree 3

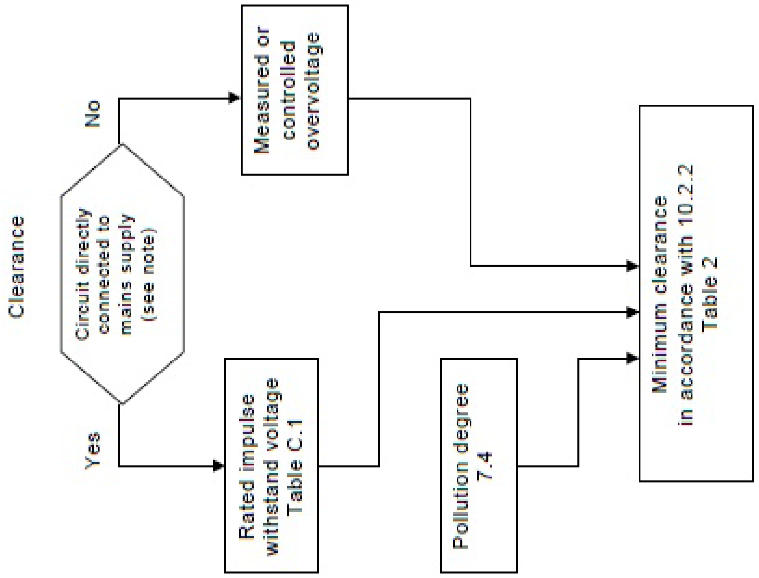
Conductive pollution occurs or dry non-conductive pollution occurs which becomes conductive due to condensation which is to be expected.

ANNEX E

(*Informative*)

DIAGRAM FOR THE DIMENSIONING OF CLEARANCES AND CREEPAGE DISTANCES


Creepage distance
Circuit directly connected to mains supply (see note)
Yes
No
Rated insulation voltage or Rated voltage
Working voltage
Pollution degree 7.4
Material group of insulation material 10.3
Minimum creepage distance in accordance with 10.3.2 Table 3


Clearance
Circuit directly connected to mains supply (see note)
Yes
No
Rated impulse withstand voltage Table C.1
Measured or controlled overvoltage
Pollution degree 7.4
Minimum clearance in accordance with 10.2.2 Table 2

ANNEX F

(*Normative*)

IMPULSE VOLTAGE TEST

The purpose of this test is to verify that clearances will withstand specified transient overvoltage. The impulse withstand voltage test is carried out with a voltage having a 1.2/50 µs wave-form as specified in IS 2071 (Part 1) and is intended to simulate overvoltage of atmospheric origin and overvoltages due to switching of low-voltage equipment.

The test shall be conducted for a minimum of three impulses of each polarity with an interval of at least 1s between pulses.

NOTE — The output impedance of the impulse generator should be not higher than 500 Ω. When testing samples incorporating system components across the test circuit, a much lower output impedance may be used.

When surge suppression is provided inside the sample, the impulse shall have the following characteristics:

a) the waveform 1.2/50 µs for the no-load voltage with amplitudes equal to the values given in Table F-1; and
b) the waveform 8/20 µs for an appropriate surge current.

Surge suppression means, if any, shall be disconnected during the impulse voltage test.

Table F-1 Test Voltages for Verifying Clearances at Sea Level Rated Impulse Withstand Voltage

Sl No.	Rated Impulse Withstand Voltage $\hat{U}$ kV	Impulse Test Voltage at Sea Level $\hat{U}$ kV
(1)	(2)	(3)
i)	0.33	0.35
ii)	0.5	0.55
iii)	0.8	0.91
iv)	1.5	1.75
v)	2.5	2.95
vi)	4.0	4.8
vii)	6.0	7.3

NOTES:

1 Explanations concerning the influencing factors (air pressure, altitude, temperature, humidity) with respect to electric strength of clearances are given in **6.1.2.2.1.3** of IEC 60664-1.

2 When testing clearances, associated solid insulation will be subjected to the test voltage. As the impulse test voltage of Table F-1 is increased with respect to the rated impulse voltage, solid insulation will have to be designed accordingly. This results in an increased impulse withstand capability of the solid insulation.

ANNEX G

(*Normative*)

ROUTINE TEST

G-1 INTRODUCTION

Routine tests are prescribed in those situations where detection on 100 percent basis is considered to be essential for safety.

G-2 GENERAL CONSIDERATIONS

In cases where the PT system does not pass the relevant test, corrective actions shall be made.

G-3 ROUTINE TEST TO BE CONDUCTED IN THE SITUATION OF REDUCED CLEARANCES

Clearances for basic or functional insulation which are less than values given in Table 2 shall be confirmed by routine test using the test of Annex F.

ANNEX H

(*Foreword*)

COMMITTEE COMPOSITION

Electrical Wiring Accessories Sectional Committee, ETD 14

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Amend No.	Date of Issue	Text Affected

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